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ORIGINAL ARTICLES.

I.—Note on some Silurian Lagenæ.

By Henry B. Brady, LL.D., F.R.S.

(PLATE XIII.)

WE are in possession of so little accurate information concerning Foraminifera of pre-Carboniferous age, that any contribution to the knowledge of the subject, however insignificant it may of itself appear, has a very distinct value. The only notices of pre-Carboniferous examples of the genus *Lagena* hitherto published occur in a provisional list of Microzoa drawn up by Professor T. Rupert Jones, F.R.S., and appended to a paper by Mr. J. Smith of Kilwinning, "On a Collection of Bivalved Entomostraca and other Microzoa from the Upper-Silurian Strata of the Shropshire District," in the Geological Magazine for February, 1881; and in a brief allusion to the same specimens in the "Report on the Challenger Foraminifera" (p. 449, etc.); but in neither case is the notice accompanied by any details.

Recently, through the kindness of my friend Prof. T. Rupert Jones, I have had the opportunity of examining a number of specimens, similar in many respects to those just referred to, collected by the late Dr. H. B. Holl in a neighbouring county and from beds approximately of the same age, and have had permission to use them in any way needful for their elucidation. Mr. J. Smith has also been good enough to lend me his original mountings with the same liberty as to their employment. I have thus been enabled to make a tolerably complete examination of the whole, the results of which are embodied in the following notes.

Prof. T. R. Jones's collection consisted of between forty and fifty specimens, typical examples of which are represented in Figs. 1–4 of the accompanying Plate. They were obtained from the base of the Wenlock Shale and from the shales of that part of the Lower-Wenlock Series known as the Woolhope Limestone; all from the Wych, Malvern.

The specimens exhibit considerable range of contour; some few are nearly globular, but the larger number are pyriform, the inferior end of the test broad and rounded, the upper portion more or less tapering, as shown in Fig. 1. Some of the shells are perceptibly

flattened on two sides, probably the result of pressure, and present an oval instead of a circular transverse section. A few specimens of smaller size (Fig. 4) are more elongate and fusiform, the two ends being drawn out nearly equally and the inferior extremity bluntly pointed. The surface of the fossils is generally rough, owing partly to the corrosion of the test and partly to the adhesion of minute fragments of the matrix. The aperture is simple and circular, often indistinct owing to the nature of the infiltrated material. The specimens vary much in point of size, measuring from $\frac{1}{25}$ to $\frac{1}{13}$ inch (roughly from 1 to 2 millim.) in length, and from $\frac{1}{60}$ to $\frac{1}{18}$ inch (0·42 to 1·4 mm.) in transverse diameter.

None of this set exhibit the long tapering neck which gives to the typical *Lagena lævis* its characteristic flask-like contour. It is true that the neck may have existed; but if so, it is remarkable that it has not in any case been preserved either in the form of external shell or internal cast, inasmuch as it remains uninjured in smaller and more delicate specimens from a not far distant locality. When first examined, it was thought possible, chiefly on account of their size, that some of these little fossils might turn out to be *Polymorphinæ*, as they bear considerable external resemblance to certain species of the "Globuline" section of that genus; but neither on the surface nor in the interior have any traces of septation been discovered. After careful comparison it does not appear that the dimensions of even the larger examples need be a serious objection to their acceptance as *Lagenæ*. It is true that either amongst recent or fossil *Lagenæ*, shells measuring $\frac{1}{20}$ inch (1·2 mm.) are very rare; but the "Challenger" dredgings furnished at least one representative of this genus (*Lagena marginata*), the diameter of which including the wing was just about the same as that of the largest of the Silurian specimens, namely, $\frac{1}{13}$ inch (2 mm.).

That some of the specimens under notice are only casts, and that the others have had the exterior much weathered and corroded, admits of no doubt; nevertheless, thin sections of the smoother more perfect individuals show unmistakable remains of the original test (Fig. 3). Where least altered this is seen to be a tolerably homogeneous wall about $\frac{1}{700}$ inch (0·036 mm.) in thickness. Treated with weak acid both the test and its subcrystalline contents dissolve rapidly, leaving only a faint trace of siliceous residue.

Compared with the foregoing, the specimens collected by Mr. J. Smith, which number about twenty in all, are of exceedingly small dimensions. In point of size they have nothing to distinguish them from average recent examples of the genus. They are mostly of the simple flask-shaped type, with rounded base and long tapering neck (Figs. 6—10), with which we are familiar as *Lagena lævis*. They vary in length from $\frac{1}{90}$ to $\frac{1}{45}$ inch (0·28 to 0·57 mm). A few have the pointed base (Fig. 5) which characterizes the varietal form known as *L. clavata*. They are for the most part casts, and it is difficult to say whether any portion of the original shell-wall remains, though transparent sections (Fig. 10) show in places a more or less distinct external layer, differing in texture from the inner subcrystal-

line mass. One or two of the fossils exhibit traces of exogenous spiral ornament round the neck (Fig. 6), a not uncommon feature of recent *Lagenæ* and *Nodosariæ*. What is more remarkable is the tendency shown in a very large proportion of the specimens to produce a local thickening of the neck in the form of an external rim or collar. Many years ago Dr. Alcock described some similar flask-like *Lagenæ* from the shore-sand of Dog's Bay, Connemara, in the following terms:—"Finely granular in texture, the surface without any raised markings, and at the base of the neck a projecting collar."[1] To these he gave the name *Lagena antiqua*. More recently Dr. Marsson has figured a costate variety with similar collar from the Chalk at Rügen, under a distinct generic name, *Capitellina*.[2] But the fact is that ectosolenian *Lagenæ* of all kinds may be found with exogenous neck-ornament, which may either take the form of a collar, as in the present case, or of a series of rings, a spiral thread, scattered spines, or a number of symmetrically disposed vertical buttresses. Recent specimens exhibiting these and other varieties of neck-ornament are figured in Plates lvii. and lviii. of the Report on the 'Challenger' Foraminifera, and it will be readily seen from them how little importance is to be attached to such features as distinctive zoological characters: nevertheless, it is exceedingly interesting to meet with like morphological conditions amongst the earliest known representatives of the genus. That the ring or collar is seldom quite symmetrical in the fossil specimens under notice, probably depends either on pressure, many of the shells being to all appearance crushed out of shape, or on the unequal weathering of the surface, perhaps on both.

In one or two instances, Fig. 11 is an example, the specimens show the remains of superficial costæ, though considerably obscured by the pressure to which they have been subjected. There need be little hesitation in assigning these to the well-known recent species *Lagena sulcata*.

The localities given with Mr. Smith's series are Lincoln Hill and the railway-cutting at Ironbridge, Dorminton Wood, Benthall Edge, Sedgley, and Woolhope.

From these gatherings we learn that at least four of the varieties of *Lagena* at present living in our seas, namely, *Lagena globosa*, *L. lævis*, *L. clavata*, and *L. sulcata*, have a genealogy reaching back to the Upper-Silurian epoch. Nothing unfortunately can be said as to the probable depth of the deposit in which they have been found, inasmuch as similar forms have been taken in the living condition at almost every depth from the littoral zone down to 2500 fathoms.

I may be permitted just to add that the accompanying Plate has been drawn by Mr. Hollick, with his accustomed accuracy, direct from the specimens.

[1] "Mem. Lit. and Phil. Soc. Manchester," 1868, ser. 3, vol. iii. p. 176, pl. iv. fig. 3.

[2] *Capitellina multistriata*, Marsson, 1878, Mitth. nat. Ver. Neu-Vorpom. u. Rügen, Jahrg. x. p. 123, pl. i. fig. 3.

EXPLANATION OF PLATE XIII.

Figs. 1-3.	*Lagena globosa*, Montagu, sp.	
	1. Lateral aspect; 2. Oral aspect.	Magnified 25 diam.
	3. Longitudinal section	× 35.
Fig. 4.	*Lagena clavata*, D'Orbigny, sp. (?)	× 35.
Fig. 5.	*Lagena clavata*, D'Orbigny, sp.	× 100.
Figs. 6-10.	*Lagena lævis*, Montagu, sp.	
	6. Small specimen with remains of spiral neck-ornament.	× 100.
	7, 8, 9. Specimens with collar encircling the neck.	× 100.
	10. Longitudinal section.	× 100.
Fig. 11.	*Lagena sulcata*, Walker and Jacob.	
	Crushed specimen; lateral aspect.	× 100.

II.—On the Discovery of the Olenellus Fauna in the Lower Cambrian Rocks of Britain.

By Prof. Charles Lapworth, LL.D., F.R.S., F.G.S.

THE brief paper on the "Stratigraphical Succession of the Cambrian Faunas in North America," communicated to *Nature* of Oct. 4, 1888, will have been read by British students of the Geology of the Lower Palæozoic Rocks with especial interest and satisfaction, as it puts an end to a controversy between European and American Geologists, and brings into harmony the sequence and palæontology of the Cambrian faunas on both sides of the Atlantic.

The remarkable fauna of the *Olenellus* or lowest Cambrian zone, originally discovered in America by Dr. Emmons in 1844, was first recognized in Europe by the late Dr. Linnarsson in 1871, in the basal zones of the Cambrian near Lake Mösen in Norway, but its typical genus *Olenellus* was then referred by him to the allied but more recent genus *Paradoxides*. This reference was corrected by Prof. Brögger in 1875; and the various brilliant papers on the Primoidial formations by this author have given the *Olenellus* fauna a marked and peculiar interest. In 1882 Linnarsson next made known the existence of the *Olenellus* fauna in Scania, at the base of the Swedish Cambrian. In 1886 the same fauna was detected by Mickwitz in the Lower Cambrian of Russia (Esthonia), and this Russian fauna has been lately figured and described in detail by Dr. Schmidt of St. Petersburgh. Still more recently (December, 1887) Dr. Holm has signalized the existence of the *Olenellus* fauna in the Cambrian of Lapland, where it was detected by Mörstell in 1885.

Thus the existence of this remarkable fossil group (the oldest well-marked fauna yet recognized by geologists) in the Lower Cambrian Rocks has been already demonstrated in three main regions, viz. (1) in the region of the Rocky Mountains; (2) in the region of North-East America; and (3) in the region drained by the Baltic Sea. But up to the present time, no notice of its presence has been recorded from the British Islands, where the oldest fauna hitherto described is that of the overlying *Paradoxides* zones, or Middle Cambrian formations.

The presence of traces of the *Olenellus* fauna in the West of England has, however, been known to myself for some time. The first recognizable fragments of the characteristic genus *Olenellus*

were detected by me on the flanks of Caer Caradoc in 1885, but they were too imperfect for description. During the summers of 1887 and 1888, Mr. H. Keeping of Cambridge, who has been collecting under my direction the characteristic fossils of the Lower Palæozoic rock-zones of the district, for the Woodwardian Museum, has obtained a sufficiency of fragments to enable us to recognize a large and well-marked species of *Olenellus*. This species possesses characters apparently intermediate between the European form *Olenellus Kjerulfi* (Linnarsson) and the undescribed American form *Olenellus Bröggeri* (Walcott, MS.); but it is so closely allied to the last-named species, that I prefer to await the publication of Walcott's diagnosis of his form before publishing its specific description. I have provisionally named it *Olenellus Callavei*, after Dr. Charles Callaway, F.G.S., who was the first to demonstrate the presence of fossiliferous Cambrian rocks in this Shropshire district, and to collect Cambrian fossils from the special strata under notice.

This lower Cambrian or *Olenellus* formation of the Shropshire area consists of two main members, viz. the basal Quartzite of Lawrence Hill and Caer Caradoc, and an overlying green sandstone, the Comley Sandstone (Hollybush Sandstone of Dr. Callaway). This formation follows unconformably upon the so-called Uriconian rocks of the district, and occurs in many localities, as at Lilleshall, the Wrekin, Caer Caradoc, Cardington, etc. In mapping this formation through the district I find that its fossils are mainly confined to the sandstones and to certain calcareous and phosphatic? beds within them. In addition to *Olenellus* we find in various localities such characteristic Lower Cambrian forms as *Kutorgina*, *Mickwitzia*? and *Acrothele*. The strata of this *Olenellus* zone are succeeded irregularly by (usually faulted against) the Shineton shales of Dr. Callaway, which have long been known to contain in their highest zones an abundant fauna of Lower Tremadoc (Upper Cambrian) age. No trace of the intermediate or *Paradoxides* fauna has yet been detected.

Although this discovery has been well known to my fellow-workers among the Lower Palæozoic Rocks of Britain, I have refrained from placing it upon record, until my identifications could be confirmed by foreign palæontologists familiar with the *Olenellus* fauna abroad. But as the specimens I exhibited at the London meeting of the Geological Congress were unhesitatingly referred to the typical *Olenellus* fauna by Mr. Walcott and Dr. Schmidt, there is no longer any excuse for withholding its publication.

The necessary geological and palæontological details will appear in due course; but as these new facts may, it is hoped, lead geologists in the meantime to a renewed investigation of the strata and fossils of the more ancient formations, it will perhaps be of service to point out that the detection of this lowest Cambrian fauna in beds superior to the Wrekin Quartzite opens out a fresh series of problems in British geology. The presence of *Olenellus* in these beds appears at first sight to fix distinctly the pre-Cambrian age of the so-called Uriconian rocks of the Wrekin and their British equivalents, and even to render the pre-Cambrian age of the Longmyndian a matter

of fair probability. With the Longmynd rocks would possibly go the Torridon Sandstone of N.W. Scotland, the Schists of St. Lo in France, the Sparagmites of Norway, etc. Again, if the Wrekin Quartzite is, as has been more than once suggested, the extension of that of Nuneaton and Durness, then our so-called Upper Cambrian of the Malverns, Central England and N.W. Scotland, may be in reality a greatly attenuated representative of the Cambrian system in general, the British extension of the remarkably attenuated Proterozoic formations of Northern and Western Europe. If so, this attenuated Cambrian may eventually be mapped as patches of an originally, fairly continuous band, ranging from Lapland, through Esthonia, Scania, Norway, Scotland, Central England, France and Spain to the Island of Sardinia. The Sardinian and Durness formations on the extreme S.E. and N.W. points of this line would agree in lithology, age, and fauna, both ranging from the base of the Cambrian up to the lowest zones of the Ordovician. It should carefully be borne in mind, however, that in the present state of our knowledge these suggestions must be regarded simply as constituting a provisional working hypothesis, of service mainly as a stimulus to future discussion, investigation, discovery, and correction.

Grouping together, however, such facts as are already known, and employing Mr. Walcott's nomenclature, we are now able to parallel his American tables by the following European equivalents:—

TABLE I.—*North-Western Europe.*

		NORWAY.	SWEDEN.	ESTHONIA.	LAPLAND.
CAMBRIAN SYSTEM.	Up. Cambrian or Olenus zones.	Dictyonema and Olenus.	Dictyonema and Olenus zones	Dictyonema	Unknown.
	Mid. Cambrian or Paradoxides zones.	Paradoxides zones.	Paradoxides	Unknown	?
	Low. Cambrian or Olenellus zones.	Olenellus zones	Olenellus	Olenellus	Olenellus

TABLE II.—*British Islands.*

		SHROPSHIRE.	ST. DAVIDS.	MERIONETHSHIRE.	CENTRAL ENGLAND.	DURNESS.
CAMBRIAN SYSTEM.	Up. Cambrian or Olenus zones.	Dictyonema and Olenus zones.	Olenus.	Dictyonema and Olenus	Dictyonema and Olenus.	Salterella and Archæocyathus fauna.
	Mid. Cambrian or Paradoxides zones	Unknown	Paradoxides	Paradoxides	Unknown	
	Low. Cambrian or Olenellus zones	Olenellus	Unknown	Unknown	Unknown	

TABLE III.—*Central and South-West Europe.*

		Central Europe.	Belgium.	Montagne Noire S.E. France.	Spain.	Island of Sardinia.
Cambrian System.	Up. Cambrian or Olenus zones.	Olenus (Hof)	Dictyonema	Olenus	?	Paradoxides and Arthacocyathus fauna.
	Mid. Cambrian or Paradoxides zones.	Paradoxides (Bohemia)	Unknown	Paradoxides	Paradoxides	
	Low. Cambrian or Olenellus zones	Unknown	Unknown	Unknown	Unknown	

III.—Note on the Genus *Actinoceras*, with Particular Reference to Specimens in the British Museum, showing the Perforated Apex of the Siphuncle.

By Arthur H. Foord, F.G.S.

THE genus *Actinoceras* was founded by Bronn in 1837,[1] upon Dr. Bigsby's figures in the Transactions of the Geological Society;[2] the chief distinguishing character being the possession of a large, dilated, and segmented siphuncle, filled with radiating deposits. The presence of a smaller internal tube with tubuli radiating therefrom and communicating with the septal chambers through the wall of the siphuncle, had not then been observed.

Fig. 1.

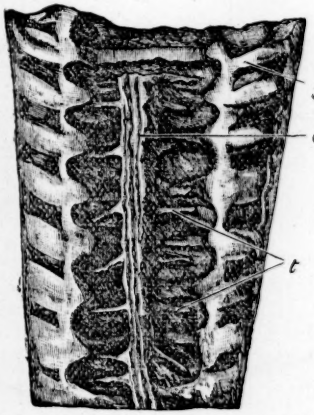

Fig. 2.

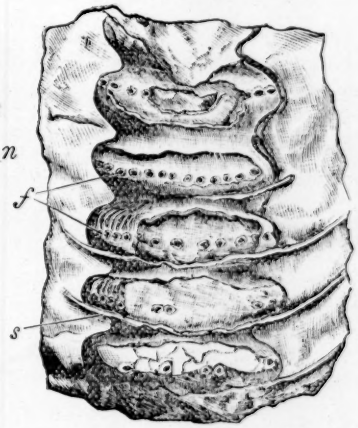

Fig. 1. Weathered fragment of *Actinoceras Bigsbyi*, showing the endosiphon, *en*, with some of its tubuli, *t* (thickened by incrustations of pearl-spar), *s*, septa. Nat. size. From the Black River Formation of Thessalon Island, Lake Huron.

Fig. 2. Fragment of the same species, showing the foramina, *f*, in the walls of the siphuncle, by which the tubuli thrown out by the endosiphon may have communicated with the septal chambers; *s*, septa. Natural size. From the Cincinnati Group, Versailles, Kentucky.

[1] Lethæa Geognostica, Zweite Aufl. Band i. p. 97.

[2] Ser. 2, vol. i. 1824, p. 198, pl. xxv. figs. 1, 2 (excl. fig. 3).

Actinoceras has been recognized, either in a generic, or in a subgeneric sense (under *Orthoceras*) by Stokes, Portlock, M'Coy, d'Orbigny (as equivalent to *Conotubularia*, Troost), S. P. Woodward, Hall (under the name of *Ormoceras*, Stokes), Saemann, Barrande, Ferd. Roemer, d'Eichwald, Owen, H. Woodward, Whitfield, Blake, and Hyatt.

The above figures have been drawn from specimens in the British Museum, and are designed chiefly to illustrate the structure of the siphuncle, in which the characters of the genus reside.

The shell in some species of *Actinoceras* (e.g. *A. giganteum*) is very large, in others it is of medium size; it is straight, or slightly bent in the young shell, and is circular or subcircular in cross-section. The sutures are usually more curved than they are in *Orthoceras*, the necks or recurved portions of the septa are very short, and are often incrusted with crystalline deposits ("anneaux obstructeurs" of Barrande), and these sometimes fill the spaces in the siphuncular cavity not occupied by the endosiphon and the tubuli proceeding from it. The siphuncle is sometimes very large in proportion to the shell, it may be equal to half the diameter of the latter; it is considerably dilated between the septa, forming thereby a series of segments of a compressed-globular shape. The first of these is broadly conical, and is perforated just above the apex with a large foramen, which served as a passage for the endosiphon from the initial chamber into the siphuncular cavity. The shelly wall of the segments is rarely preserved, but their calcified lining membrane beneath is very characteristic, presenting a series of longitudinal folds or wrinkles. The endosiphon (Fig. 1, *en*) is provided with a distinct wall, and gives off, at intervals between the septa, a number of radiating canals or tubuli (Fig. 1, *t*) which are seen to penetrate the wall of the siphuncle, and thus to communicate with the septal chambers, to which they may have conveyed blood-vessels, as suggested by Owen.[1]

The structure to which I desire now to direct particular attention is the perforation in the apex of the first segment of the siphuncle. There can be no doubt that this is strictly analogous to the perforation in the apex of the siphuncle in *Piloceras*,[2] and that through this opening the endosiphon passed from the initial chamber into the siphuncular cavity.

The rare preservation of the apical extremity of any of the straight shelled Cephalopods of the genera *Orthoceras*, *Endoceras*, *Actinoceras*, or *Piloceras*, imparts a peculiar interest and value to the specimens which are the subject of the latter part of this note.

It is to be hoped that by diligent search other specimens may yet be found which will throw more light upon these remarkable structures.

[1] Palæontology, 1860, p. 85.

[2] See paper on this genus by the present writer in the GEOLOGICAL MAGAZINE for December, 1887.

Fig. 3. Fig. 4.

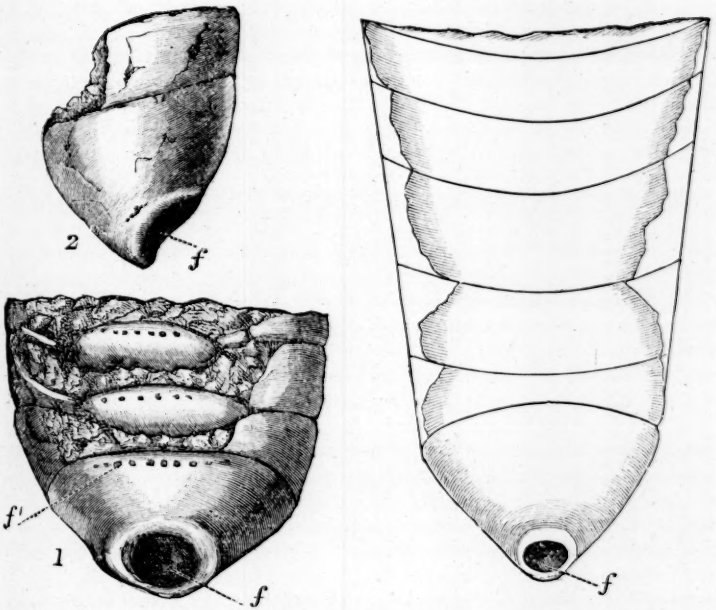

Fig. 3. 1, front view of a weathered fragment of the apical extremity of *Actinoceras Bigsbyi ?*; showing (*f*) the large foramen and the row of minute foramina situated at *f'*, the most elevated part of the siphuncular segments. Natural size. From the Black River Formation (?), Igloolik Island, Arctic America.

Fig. 4. View of part of a much eroded fragment of an *Actinoceras*, consisting of the internal cast of some of the septal chambers, and the siphuncular segment with its foramen (*f*). Three-quarters natural size. Fig. 3.—2, side view of part of the same specimen, showing the lateral position of the large foramen (*f*) in relation to the apex. Natural size. From the Great Slave Lake, British North America.

IV.—Some Definitions in Dynamical Geology.

By W. J. McGee;

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In view of the active discussion of the problems of earth-movement and mountain-growth now current, certain fundamental definitions, growing out of the discrimination of processes commonly confounded but really distinct, seem to be timely.

The various processes with which the geologist has to deal fall naturally into two principal and antagonistic categories and five subordinate and supplemental categories; and each category, great and small, comprises two antagonistic classes of movements or agencies.

The initial geologic movements (so far as can be inferred from the present condition of the rocks of the earth) were distortion or

displacement of the solid or solidifying terrestrial crust in such manner as to produce irregularities in the surface of the globe. These are the movements involved in mountain-growth and in the elevation of continents; they have been in operation from the earliest eons recognized by the geologist to the present time; and their tendency is ever to deform the geoid and produce irregularity of the terrestrial surface. Such movements have been designated "displacement," "diastrophism," etc.; but for the present purpose they may be called simply *deformation*, and the quality of the movement may be characterized as *diastatic*. They are partly vertical (though there is perhaps always a horizontal element) and are most easily measured from a fixed datum-plane—such as sea-level—and are therefore commonly separated into *elevation* and *depression*.

The second great category of movements comprises the various processes of aqueous erosion and deposition initiated by the primary deformation of the terrestrial surface. By these processes mountains and continents are degraded, and seas and lakes are filled with their debris; they, too, have been in active operation from the dawn of geologic history to the present; and they ever tend to restore the geoid by obliterating the irregularities of the terrestrial surface produced by diastatic movement. Collectively the processes may be called *gradation*; and the antagonistic operations comprehended under the term are respectively *degradation* and *deposition*.

A subordinate class of processes by which the rocks of the earth are formed or affected is the extravasation of lavas and other volcanic matter from beneath the surface, the outflow of subterranean waters containing solid matter in solution, and the escape of mineral-charged gases, together with the consequent collapse of cavities and other crust-movements. These processes have been in operation throughout geologic time, though perhaps with diminishing activity; they have added materially to the superficial strata of the earth; and they have modified the geoid not only by addition without, but by the commensurate loss within and consequent deformation and structural alteration. The various operations are commonly comprehended under the term *vulcanism*; and the two subordinate classes or processes of antagonistic tendency which it comprises are *extravasation* and its converse. The vibratory movements usually called seismic probably accompany both diastatic and volcanic movements under certain conditions.

The second subordinate category of processes by which the rocks themselves and the operations of the second great category of geologic processes are modified, comprises the chemic and chemico-mechanical alterations in structure of the earth's strata brought about by the action of percolating water, air, and other gases, the effects of frost and other variations in temperature of the exterior of the earth, the rise of the isogeotherms beneath the areas of degradation, the heat resulting from deformation, etc. These processes have affected the rocks ever since the solidification of the planet, but probably with progressively diminishing intensity; by them the rocks exposed to degradation are disintegrated, decomposed,

and softened, and degradation is thereby accelerated; by them the soft sediments are first lithified and then (sometimes) subsequently metamorphosed; and by them the chemic complexity and structural heterogeneity of the terrestrial crust have been largely produced. The various processes are processes of *alteration;* and they comprise *lithifaction* and its converse (*decomposition* and *disintegration* combined) in their various phases, or rock-formation and rock-destruction.

There is another subordinate category of processes which are intimately allied to those of the second great category, viz. *glaciation.* Only two clearly defined periods of extensive glaciation—both late Tertiary or Quaternary—are generally accepted, though others are recognized by different geologists; in general the tendency of glaciation is to obliterate surface-irregularity, both by grinding down elevations and filling up depressions, and thus to perfect the geoid; but glaciation may also accentuate pre-existing irregularities of the surface, certainly by moraine-building and probably by basin-cutting, and must therefore be set apart as a unique agency in the modification of the external configuration of the globe. The general process comprises *glacial construction* and *glacial destruction.*

The fourth subordinate category includes the effects of aerial circulation, directly upon land surfaces, and indirectly through wave and current-action under and about water surfaces. These processes have been in operation throughout geologic time, but so indolently that little trace of their products is found save among recent phenomena; in general the tendency is to reduce elevations and fill depressions, and thus to merge into gradation; but there is also a tendency to build dunes, beaches, and banks, and to excavate both subaerial and subaqueous basins, and thus to produce certain minor irregularities of the earth's surface as well as to perpetuate others. The general process is *wind action* or *eolation;* and its subordinate processes are, like those of other categories, antagonistic.

There is a final category which is in part allied to alteration, but which is in part unique, viz. the chemic, chemico-mechanical, and dynamic action of organic life. Ever since the terrestrial crust became so stable as to retain a definite record of the successive stages of world-growth, life has existed, and by its traces has furnished the accepted geologic chronology; at first the organisms were simple and lowly and affected the rocks chemically through the processes of growth and decay, as do the lower plants and animals of the present; later, certain organisms came to contribute largely of their own bodily substance to the growing strata; and still later the highest organisms, with man at their head, have come to interfere with gradation, alteration, and eolation dynamically, and thus to directly or indirectly modify the various interrelated geologic processes—indeed it is probable that in populous plains at least the several natural processes combined are less potent factors in geologic development than human action alone. The vital forces are too varied in action to be conveniently grouped and comprehensively named.

This simple classification of elementary processes, which appears

to practically traverse the domain of geologic science, is summarized in the accompanying table :—

Classification of Geologic Processes.

Principal Categories.	1. Deformation	Elevation Depression
	2. Gradation	Degradation Deposition
Subordinate Categories.	1. Vulcanism	Extravasation Converse of do.
	2. Alteration	Lithifaction Converse of do.
	3. Glaciation	Glacial construction Glacial destruction
	4. Eolation	Eolic construction Eolic destruction
	5. Vital action	Various constructive and destructive processes.

The first principal category of processes is supplemented by the first subordinate category, and both tend to produce departures from the simple geoidal form or *heteromorphism*. Play is thus given to the operations of the second principal and the last four subordinate categories, which are also intimately related, and, combined, tend to produce *heterogeneity* in the external shell of the earth. The joint result is *differentiation* of the earth's exterior—the converse of those processes of concentration and segregation by which the planet was originally formed; and the passage from the stage of segregation to that of differentiation represents at the same time the senescence of the planet and its entrance into the state recognized by the geologist *per se*.

Now the processes involved in heteromorphism are generally obscure, and many of them are beyond the reach of observation. Here, moreover, the domain of the physicist and astronomer on the one hand and that of the geologist on the other overlap; here the physicist contributes principles and makes deductions of great suggestiveness and often of high value to the geologist, and here the geologist is an agnostic and assails the deductions of the physicist, and, too often for the good repute of physical science as applied to geologic research, breaks them down; here, too, the geologist is equally an agnostic with respect to his own conclusions of higher rank than mere generalizations, and assails every inference of his fellows and, unless he be rash indeed, guards his own course at every step and feels his way cautiously through the tangled maze of ambiguous testimony recorded in the crumpled strata of the mountains; here the dearth of clear definitions of the various processes of deformation is doubtless due to the hesitation of physicist and geologist alike to confidently enter the purview of the adjacent domain; but here tentative definitions (at least) are especially needed, and indeed essential to the progress of research.

Within about a decade an inference of moment concerning diastatic movement has been made (largely by American geologists), viz. that certain orogenic and even volcanic movements are consequent

upon gradational transfer of matter—that the earth is in a condition of isostacy, and that as the rains bear detritus from the mountains into the seas, the unloaded mountains rise and the loaded sea-bottoms sink, and thus that a part of the deformation of the outer shell of the earth and certain volcanic movements are consequent upon the processes of gradation. Although at first blush it might appear that the great problem of earth-movements is solved by this discovery, consideration shows that these consequent diastatic and volcanic movements are but the indirect result of antecedent movements for which no adequate cause has been assigned (unless the "contraction theory" be accepted); for it is evident that if deformation were dependent solely upon transfer of sediments, it would diminish with the lapse of time, that the mechanism of mountain elevation would soon become clogged by increasing friction, and that the terrestrial surface would quickly be graded so completely that further movement would cease; yet the rocks record diastatic activity throughout geologic time, now increasing, now diminishing, but on the average probably increasing rather than diminishing, and perhaps as potent to-day as during any past time. So the processes by which heteromorphism are produced are separable into two classes—that depending upon transfer of sediments, which may be designated *consequent*, and that for which adequate cause has not yet been assigned, which may be called *antecedent*. Discriminated upon a different basis they fall into classes approximately but not exactly coinciding with these, viz. *orogenic*, or mountain-making movements, and *epeirogenic*,[1] or continent-making movements.

Now it is only within a decade that diastatic and volcanic movements of the consequent class have been separated from the primary class; even yet there are geologists who do not recognize the distinction; and so most of the hypotheses thus far framed to explain the deformation of the terrestrial shell rest upon the explicit or implicit assumption that all the movements involved belong to the class here called antecedent. The appositeness of the definitions therefore needs illustration.

A primary hypothesis ascribed the corrugation of the terrestrial crust to contraction of the interior of the earth accompanying secular cooling more rapid than that of the exterior shell. The common conception of the mechanism of this process was familiarly illustrated by likening the corrugated globe to a withered apple, and the inequalities of the terrestrial surface to the wrinkles on the apple's skin; and to the surprise of most American geologists, at least, this hypothesis has been prominently advocated within a year or two. Fisher and others have shown, however, that the postulated cause is far from commensurate with the observed effect—that even upon the most liberal estimates of radial contraction due to secular cooling, the concomitant tangential contraction would scarcely produce a tithe of the observed corrugation of the terrestrial crust. Dutton maintains that equitable contraction of a spheroid would not tend to produce corrugations such as those characterizing the earth's

[1] A term proposed by Gilbert.

crust. Taylor and others have pointed out that any corrugations resulting from secular cooling of the terrestrial shell in combination with the stresses resulting from precession, nutation, retardation of axial rotation, etc., would tend to assume certain definite directions, and that these directions do not coincide with those of the mountain ranges actually existing nearly enough to give countenance to the hypothesis. Reade and others have recently found that tangential contraction due to secular cooling must have been confined to a limited shell, even thinner than the strata known to be corrugated; and it might be demonstrated that the concentration of montanic corrugation along certain lines, leaving vast intervening areas quite undisturbed, does not agree with the hypothesis, and could not occur in accordance with it under any conditions of rigidity and internal friction of the rocks which it is reasonable to assume—the arches are too long and rest too heavily upon the terrestrial nucleus to convey crushing strains to their extremities without greater compression about their keystones. While therefore the "contraction theory" is so conditioned as to explain antecedent deformation, it cannot be accepted as a quantitatively adequate cause of such movement.

There is another hypothesis of earth-movement frequently regarded as alternative with the last. Geologists and physicists have long ageed that lines of mountain growth usually coincide with zones of rapid deposition during former times, and that in these zones the deposition was accompanied by depression (thus foreshadowing the later conception of consequent diastatic movement); they have agreed further that in consequence of the combined sinking and thickening of the crust, the couches of equal temperature within the earth—the isogeotherms—must rise in the sediments until strata formed at the temperature of the sea-bottom are heated to hypogeal temperatures; and they have inferred that the consequent expansion of sediments developed stresses whereby further heat was generated, and that the rocks were thus flexed, corrugated, and sometimes metamorphosed. This hypothesis, in one form or another, has had currency for a generation. It has indeed been questioned whether the assumed cause is commensurate with the effect—whether the expansion of sedimentary beds by local rise of isogeotherms from time to time and from place to place is sufficient to explain the extensive and profound corrugation observed in the mountains of the earth, the enormous shortening of the Alpine arc as observed by Heim and others, and the shortening of the Appalachian arc by 60 miles as computed by Claypole; but Reade has quite recently pointed out what the early advocates of the hypothesis had overlooked, viz. that since the strata are confined laterally, any expansion due to rise of temperature must take place vertically, so that a given rise of temperature would produce thrice the elevation and perhaps thrice the corrugation inferred by the older geologists; and the hypothesis has thus been rendered more acceptable.[1] But

[1] Singularly, Reade and all his predecessors neglected an important (in the judgment of the writer the most important) factor in the movements contemplated

it is evident that all such movements belong to the consequent class as above defined, and hence that the hypothesis utterly fails as an explanation of the antecedent deformation by which active geologic processes were initiated early in the history of the earth, and by which these processes have ever since been maintained. It cannot be too strongly emphasized that without continents zones of deposition could not be formed, and that continents could not come into being without antecedent deformation. The case is simple. Either (1) the primaval earth was highly rugose, and gradation and consequent deformation have always been employed in reducing the rugosity, or else (2) a general deforming force of unknown cause and value has always been in operation—either the earth is a clock once wound up and ever since running down, or it is a prime motor whose mechanism may be obscure, but whose energy is ever renewed within itself. To the working geologist, constrained by the inexorable logic of facts, there is but one choice between these alternatives; the Palæozoic earth, at least, was less rugose than the present, and although diastatic activity has varied, it has not declined with the ages; and the grander earth-movements are in progress to-day as proved by a score of examples of continental oscillation, and is perhaps as active now as at any time in the past.

So the processes by which heteromorphism of the globe are produced (deformation and vulcanism combined) comprise (1) movements antecedent to gradational transfer of matter, predominantly epeirogenic, or continent-making, and predominantly diastatic, for which adequate cause is not yet assigned; and (2) movements consequent upon gradational transfer of matter, predominantly orogenic, or mountain-making, and both diastatic and volcanic. It is important to discriminate these classes of movements.

in the hypothesis. Lines of sedimentation are the margins of continents, and the sediments are laid down not upon horizontal surfaces, but upon seawardly sloping bottoms; so the sediments do not form horizontal beds, but take a variable seaward slope determined by marine currents, wave action, etc. Thus the mass of sediments is collectively in the condition of a mass of snow upon a roof or upon a mountain side, *i.e.* in a condition of potential instability or *inequipotentiality*. If the mass is stable in either case, it is because the friction among the particles exceeds the attraction of gravitation upon the particles; it is obvious that if particle friction were reduced by augmentation of temperature or by alteration of constitution, or if the efficiency of gravitation were increased by addition to the mass, the point of stability might be passed, when the mass would move in the direction of the slope; and it is equally obvious that if an inequipotential mass expand, the resulting movement will not take place equally in all directions, but mainly or wholly in the direction of least resistance, which is that of the slope. Since the sediments fringing continents are in a condition of inequipotentiality, any movement due to the rise of isogeotherms or other cause must take place in a single direction; and it might not be limited to that due to expansion, for other factors co-operate. Supplemented by this additional conception, the hypothesis of mountain growth so ably advocated by Herschel, Babbage, Hall, Dana, Le Conte, Reade, and a score of others, appears to gain much in acceptability.

V.—On the Cretaceous Selachian Genus *Synechodus*.

By A. Smith Woodward, F.G.S., F.Z.S.,
of the British Museum (Natural History).

More than forty years ago the detached teeth of Hybodont Sharks were recognized by Reuss[1] in the Cretaceous rocks of Bohemia, and these were referred to the genus *Hybodus* under no less than eight specific names. About twenty years later, evidence of a somewhat similar Selachian was discovered by Mr. William Davies and Mr. S. J. Mackie, in the Lower Chalk of Kent; and the cartilages of the jaw, with a few teeth, were briefly described by the last-named geologist[2] under the name of *Hybodus dubrisiensis*. In 1886, the present writer pointed out,[3] from more recently discovered specimens, that the English Cretaceous species was more specialized in every respect than any of the typical forms of *Hybodus*; and quite lately it has been proposed[4] to regard this fossil as generically distinct, with the new name of *Synechodus*.

It now appears, indeed, that "*Hybodus*" *dubrisiensis* is much more nearly related to *Palæospinax* than to the typical *Hybodus*. This is well shown by the almost complete dentition of one jaw, exhibited in a fine specimen from the Chalk of Sussex, preserved in the Willett Collection in the Brighton Museum; and the opportunity of making known this important new fossil—kindly afforded by Henry Willett, Esq., and the Chairman of the Museum Committee (Edward Crane, Esq.)—seems a fitting occasion for briefly summarizing our present knowledge of the skeletal and dental characters of the fish. All the cartilages are only superficially calcified, but the thin hardened layer is comparatively resisting, and it has thus been sufficiently preserved in some cases to indicate the precise contour of several parts of the skeleton.

Head.—Nothing worthy of note has been observed in connection with the cranium; but the mandibular and hyoid arches are well known and of great interest.[5] A facette upon the superior border of the pterygo-quadrate cartilage may almost certainly be regarded as indicating a post-orbital articulation with the cranium; and in correspondence with this arrangement the hyomandibular element is remarkably slender. There is thus considerable resemblance between the skull of *Synechodus* and that of the existing *Notidanus*; both exhibiting a very primitive condition of the mandibular and hyoid arches, and showing a tendency to specialization in one and the same direction.

[1] A. E. Reuss, "Verstein. böhm. Kreideform.," 1845–6, pt. i. p. 2; pt. ii. pp. 97, 98, with figs.

[2] S. J. Mackie, "On a new species of *Hybodus* from the Lower Chalk," The Geologist, vol. vi. (1863), pp. 241–246, pl. xiii.

[3] Smith Woodward, "On the Relations of the Mandibular and Hyoid Arches in a Cretaceous Shark (*Hybodus dubrisiensis*, Mackie)," Proc. Zool. Soc., 1886, pp. 218–224, pl. xx.

[4] Smith Woodward, "A Synopsis of the Vertebrate Fossils of the English Chalk," Proc. Geol. Assoc. vol. x. (1888), p. 288.

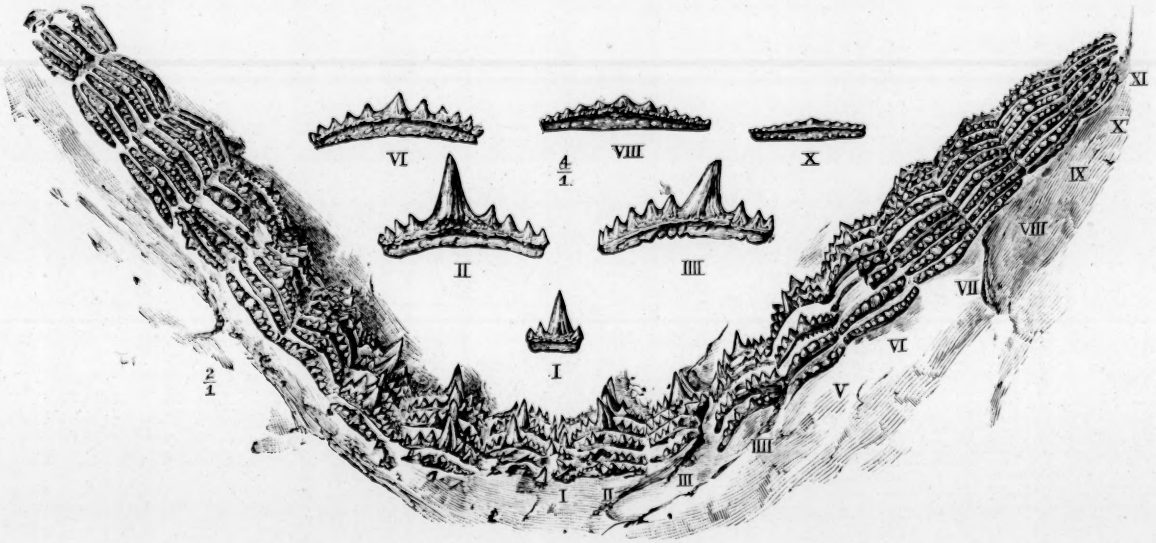
[5] See figures in Proc. Zool. Soc. 1886, pl. xx.

Dentition.—In Mr. Willett's example of the dentition of *Synechodus dubrisiensis*, already referred to, about 140 teeth are displayed in their natural relative positions; and the fossil is shown, of twice the natural size, in the accompanying Woodcut, with the first and second teeth and one of each of the alternate succeeding series, still further enlarged separately. There are eleven dental series upon either ramus of the jaw, each of those posteriorly placed comprising as many as eight or nine teeth, while those near the symphysis have not more than six. There is no median symphysial row of teeth, and the first pair (I.) is extremely small. In the latter the principal coronal cusp is long and slender, its height being equal to the entire width of the tooth; and there are two small denticles in front and one behind. The teeth of series II. are nearly four times as wide as those of no. I., with the principal coronal cusp still very prominent and flanked in front and behind by three large denticles and one smaller point, of which those behind are the more widely spaced. The teeth of series III. are very similar to those of no. II.; but in the teeth of series IIII. and V. the principal cusp rapidly becomes stouter and less elevated, and there are five denticles in front, while only three or four can be distinguished behind. In series VI. to IX. the size of the teeth only gradually decreases backwards, but the principal cusp becomes very short and stout, thus more resembling the lateral denticles, which are still very numerous and placed well apart. In these teeth, the denticles are five or six in number, both in front and behind. In series X. the teeth are only about two-thirds as wide as those of no. IX., while those of series XI. are still smaller by one-half; and in both of these all the coronal prominences have become insignificant, though yet faintly indicated by a beaded contour. The base of the crown in all the teeth is marked by fine reticulating wrinkles, and the lower portion of the coronal cusps is often vertically striated.

On comparing the teeth of this fossil with the few examples of *S. dubrisiensis* already described, one important difference will at once be noted. Whereas in Mr. Willett's specimen, the most anterior teeth are very small and delicate, some other fossils exhibit teeth in a corresponding position of a very large and robust character, with several feebly marked denticles on each side.[1] One specimen in the British Museum (No. 41675) suggests that the latter pertain to the upper jaw; and, in that case, the Brighton fossil may represent the lower dentition. There can be no doubt, indeed, that the two types belong to one and the same species; but whether the differences in the anterior teeth depend merely upon their pertaining to one or the other jaw, or whether one type is referable to the male and the other to the female, remains yet to be determined. The present writer has examined no specimen in which the small teeth and the robust teeth occur together.

Axial Skeleton of Trunk.—The vertebral centra are well calcified; but only the anterior portion of the body is yet known (Brit. Mus.

[1] Proc. Zool. Soc. 1886, pl. xx. fig. 3*a*.



Dentition of *Synechodus dubrisiensis*, Mackie sp.; Chalk, Sussex.

[Collection of Henry Willett, Esq., F.G.S., Brighton Museum.]

No. 49032). All the vertebræ are distinctly "asterospondylic" in structure, and the centra are mostly deeper than long.

Appendicular Skeleton.—Each half of the pectoral arch consists of a single slender cartilage, produced upwards into an attenuated extremity, and very similar in form to the corresponding element both of *Palæospinax* and of *Hybodus*.

External Dermal Structures.—A fine, apparently sparse shagreen covered at least certain portions of the body; and a few of the granules are well preserved upon one small fragmentary head in the British Museum. Some granules are smooth and quadrate in form, but many are more or less oval, ridged and grooved in the direction of their long axis.

Affinities.—The dentition of *Synechodus*, as long ago recognized, indicates the systematic position of the fish to be in the Hybodont section of the great family of Cestraciontidæ. Many of the detached teeth cannot be distinguished from those of *Hybodus*; but, as already remarked, a comparison of the complete dentition described above with the dentition of *Palæospinax priscus* from the Lower Lias of Lyme Regis,[1] shows a still more exact correspondence in almost every feature. With *Palæospinax*, also, *Synechodus* agrees in the character of its shagreen; and the vertebræ in the Cretaceous genus only differ from those of the Liassic fish in their slightly higher stage of development. The fact that no Selachian dorsal fin-spines have hitherto been found in the Chalk, except small smooth spines indistinguishable from those of *Cestracion* and *Palæospinax*, is also suggestive of the correspondence of the two genera under comparison in the nature of these dermal defences. The more specialized character of *Synechodus*, indeed, is the only justification at present for its generic separation; and it may be added that *Palæospinax* is certainly one of the Cestraciontidæ (Hybodontidæ), being definitely separated from the Spinacidæ, with which it has hitherto been associated, by the possession of a distinct anal fin (Brit. Mus. no. P. 1296).

Distribution.—The earliest evidence of *Synechodus* with which the writer is acquainted occurs in the Neocomian of Kent, whence have been obtained some anterior teeth with an attenuated principal coronal cusp. Other teeth have been described from the Lower Cretaceous of Amuri Bluff, New Zealand, under the name of *Odontaspis sulcata*.[2] A few teeth, of still another specific type, are met with in the English Gault. A single example from the Cambridge Greensand is preserved in the collection of Thomas Jesson, Esq., of Northampton. *S. dubrisiensis* occurs in the Lower, and probably also in the Upper Chalk; there is evidence of other forms in the uppermost Chalk of Norfolk; and one or more species are represented in the Lower Chalk of Saxony, Bohemia, and Russia.

[1] Sir Philip Egerton, "Figs. and Descrips. Brit. Organic Remains" (Mem. Geol. Surv.), dec. xiii. (1872), pl. vii.

[2] J. W. Davis, "On the Fossil Fish Remains of the Tertiary and Cretaceo-Tertiary Formations of New Zealand," Trans. Roy. Dublin Soc. [2] vol. iv. (1888), p. 25, pl. v. figs. 11—13.

VI.—Note on the Occurrence of a Species of *Onychodus* in the Lower Old Red Sandstone Passage Beds of Ledbury, Herefordshire.

By A. Smith Woodward, F.G.S., F.Z.S.;
of the British Museum (Natural History).

During a recent visit to the University Museum at Oxford, I observed in the Grindrod Collection an interesting small fossil apparently adding to the known fauna of the Ledbury Passage Beds a remarkable type of fish, hitherto only met with in the Middle and Upper Devonian of the United States. Through the kindness of Professor Green, I have since had the opportunity of studying this specimen in London; and it is shown, of twice the natural size, in the accompanying Woodcut. It may be regarded as an imperfect example of the so-called "intermandibular arch" of the extinct ganoid, *Onychodus*, described by Prof. Newberry[1] from the Corniferous Limestone of Ohio, and the Chemung Group of Delaware County, New York.

The fossil is, for the most part, only displayed in section, owing to the unfortunate plane of fracture of the matrix; but the uppermost of the vertical series of teeth, as preserved, exhibits the unbroken outer surface for about half of its length, and this enables

Intermandibular Arch, or Presymphysial Bone, of *Onychodus anglicus*, A. S. Woodw., Lower Old Red Sandstone Passage Beds, Ledbury, Herefordshire. Twice nat. size. [Grindrod Collection, University of Oxford.]

the cylindrical form and unornamented character of the dental crown to be determined. There is a curved plate for the attachment of the teeth, scroll-shaped in section, the attenuated lower extremity being considerably in-rolled. The teeth have the *appearance* of being directly fused to the base, arranged along its convex side; and they obviously decrease in size from above downwards, though the distal portions of all but the uppermost are considerably destroyed. The upper tooth, as already remarked, is slender and cylindrical in section, with a smooth surface, perhaps only marked with one faint longitudinal groove on each side; and the distal half of the crown is sharply directed upwards. Beneath this tooth are prominent remains of three others, similarly shaped, and closely placed together at their bases; and evidence of either one or two still smaller teeth is distinguishable yet more inferiorly.

Ferruginous matter has penetrated the interstices of the fossil,

[1] J. S. Newberry, Geol. Survey of Ohio, vol. i. pt. ii. (Palæontology), pp. 296–302, plates xxvi., xxvii.

and so rendered its minute structure to a certain extent recognizable. The base is conspicuously vascular, except in a thin, sharply-defined layer forming the concave margin; and each tooth is likewise constituted mostly of vascular tissue, with a thin, dense outer layer. A very small cavity also appears to occupy the centre of each dental cone.

The genus *Onychodus* was originally founded by Prof. Newberry upon detached teeth similar to those of the Ledbury fossil, discovered in the Corniferous Limestone of Ohio. These teeth were at first supposed to be referable to the great Placoderm, *Macropetalichthys*, occurring in the same beds; but their discovery soon afterwards in connected series naturally led to the suspicion that they might rather pertain to a Selachian. Still later, the problematical dentition was found associated with cranial plates, tooth-bearing maxillæ and dentary bones, and numerous round scales; and in 1873, complete proof of its exact position in the jaws of the original fish had at last been obtained. It appears that the slender bony arch is a mesial element fitting in a well-marked groove at the symphysis of the dentary bones; while the long, sigmoidally-curved teeth project directly forwards in front. The head-bones are numerous, and the large round scales are deeply overlapping, being ornamented much like those of *Glyptolepis*; whence Prof. Newberry concludes that *Onychodus* was most probably one of the great group of Crossopterygidæ.

The fossil now under discussion is thus referable to a "Ganoid," and it evidently represents the presymphysial bone of some later genera (e.g. *Aspidorhynchus* and *Belonostomus*), even if it be not altogether homologous with that element. The appearance of the series of teeth is at first suggestive of a dental succession like that of Selachians; and in this connection it would be interesting to know precisely the histological characters of the fossil. Though comparatively abundant, none of the American examples seem to have been yet examined microscopically; but it is to be hoped that some such investigation may soon be made—more especially as comparisons have already been suggested with the problematical Carboniferous *Edestus*.[1]

The coiling of the inferior extremity of the base in the Ledbury fossil has not hitherto been noted in the American specimens; and this may be either a normal feature, or merely a post-mortem accident to a possibly pliable tissue. Other differences, however, of at least specific value, are also observable between this and the described American types of "intermandibular arch": the new fossil is much smaller than those already known, and the size of the teeth is apparently less uniform. Awaiting further evidence, therefore, for more precise definition, the species of the Ledbury Passage Beds may receive the name of *Onychodus anglicus*.

[1] Fanny R. M. Hitchcock, "On the Homologies of the so-called Spines of *Edestus*," Proc. Amer. Assoc. Adv. Sci. 1887. See also J. S. Newberry, "On the Structure and Relations of *Edestus*," Ann. New York Acad. Sci. vol. iv. (1888), p. 116.

VII.—Note on Mr. I. C. Russell's Paper on the Jordan-Arabah and the Dead Sea.

By Professor Edward Hull, LL.D., F.R.S.

I HAVE been very much interested in reading Mr. Russell's two communications published in the Geological Magazine for August and September last.[1] The analogy which he draws between the history of the Dead Sea valley and that of some of the lake valleys in the western part of North America is instructive as showing how similar physical features can be accounted for on similar principles of interpretation over all parts of the world. Mr. Russell very properly draws attention to the paper by his colleague Mr. G. K. Gilbert on "The Topographical Features of Lake Shores," in which principles of interpretation of physical phenomena are laid down applicable to lakes both of America and the Jordan-Arabah valley.[2] With some of Mr. Russell's inferences regarding special epochs in the history of this valley I am very much disposed to agree; more particularly in reference to the mode of formation of the Salt Mountain, Jebel Usdum; or rather, of the salt-rock which forms the lower part of its mass. If this interpretation be correct, it removes the difficulty of understanding why the rock-salt is confined to one small corner of the lake, which, at the time the salt was in course of formation, was vastly more extensive than at present.

The case of the arm of the Caspian known as Kara Bughaz, which Mr. Russell cites, seems remarkably apposite to that of the Southern bay of the Dead Sea; and I feel obliged to the author for his suggestion. In reference to Mr. Russell's statement that "we ought to look for an unconformity between the upper and lower lake beds due to the erosion of the lower member," I wish to take this opportunity of referring again to the peculiar structure in the rock-salt near the northern end of Jebel Usdum, where the white laminated marls, forming the upper part of this plateau, are seen resting horizontally on a mass of rock-salt, having an oblique structure; that is, traversed by planes sloping southwards at an angle of about 20°–25°. I made a sketch of this part of the cliff in my note-book, but from inability, through lack of time, to examine into the phenomena with more care than can be done from horse-back, I thought it prudent not to refer to the matter in the Geological Memoir,[3] further than to notice it.

My special purpose in this communication is to offer some additional information to that already given on the question whether or not the Jordan-Arabah valley originally communicated with the ocean through the Gulf of Akabah. Mr. Russell is not satisfied with the information already before him regarding the nature of the watershed of the Arabah. I have, therefore, referred back to my

[1] "The Jordan-Arahab Depression and the Dead Sea," Geol. Mag. Aug. and Sept. 1888, pp. 337–344 and 387–395.

[2] Gilbert, Fifth Annual Report U.S. Geological Survey (1883–84).

[3] Memoir on the Physical Geology of Arabia-Petræa and Palestine, p. 84 (1886).

notes, which are rather full on this very subject, though I did not consider it necessary to give them *in extenso* in the Geological Memoir, or in Mount Seir. On referring to the large Map of the Arabah Valley in the Memoir (facing p. 137), it will be seen that the watershed (Lat. 30° 10′ N.) is formed partly of a limestone ridge, called Er Rishy, and partly of "gravel of the Arabah." This gravel extends for several miles down both slopes of the watershed, and is sometimes overspread by blown sand, or else by alluvium. On the west side it is bounded by the steep, often precipitous, cliff of the rocks forming the eastern border of the Desert of the Tîh (Badiet et Tîh), and on the east by those of the Edomite hills and escarpments; and at its lowest part rises about 700 feet above the level of the Mediterranean and Red Seas,[1] and therefore nearly 2,000 feet above the present surface of the Dead Sea. On approaching the watershed, or saddle, from the south, it appears as a level line stretching from the northern end of Er Rishy to the foot of the rugged hills of Edom, and about half a mile in length. It is formed of sand and gravel of considerable thickness overlying the limestone which rises from beneath on the eastern side, and which is broken off by the great Jordan-Arabah fault against the granitoid and other crystalline rocks, which here form the base of the Edomite range. This gravel has all the appearance of a fluviatile, or alluvial, deposit, formed by the streams which in flood time descend from the hills to the east; and it is well laid open to view in one of these streams, which ultimately joins the River Jeib. Between this watershed and the first of the terraces which can, with any degree of certainty, be referred to a lacustrine origin, there is a distance of over twenty miles, and a vertical fall of about 700 or 650 feet; and as our party was scattered over the valley, we could not have failed to detect remains of such lacustrine deposits, if any such existed, above the level of those we encountered at our camp of the 12th December, 1883, at Ain Abu Werideh: at a level approximately that of the Mediterranean, and 1292 feet above that of the Dead Sea.[2] These horizontal beds of white marl with shells, sand, and shingle, was an entirely new feature to us all; and no doubt remains on my mind that they indicate the highest level to which the waters of the ancient Jordan-valley Lake formerly rose.

An admission on my part that the waters of the Jordan valley ever were in connection with those of the outer ocean through the Gulf of Akabah can only be made from the point of view that, during the formation of the Jordan-Arabah line of depression by the displacement of the strata along the great fault, and when the whole region was rising from beneath the waters of the ocean in Miocene times, some such connection existed for a limited period of time; but this epoch in the history of the valley was separated by a long interval from that of the present Dead Sea, even when standing at a level of 1300 feet above its present surface. From the time that

[1] M. Vignes' determination is 787 feet (240 mètres); that of Major, now Colonel Kitchener, is 660 feet; and that of Mr. Reginald Laurence by aneroid 650 feet.

[2] Mount Seir, p. 99; Geological Memoir, p. 80.

the outer waters of the ocean were dissevered from those of the Jordan-Arabah lake by the up-rise of the land, there is no evidence that there was ever any subsequent connection by means of a stream flowing down from the North into the Gulf of Akabah. The closest approximation which, according to my view, these inner and outer waters ever made towards each other is represented in the sketch-map of that whole region in page 72 of the Geological Memoir, where a tract of ground of about 40 miles in length and rising to 700 feet in height is represented as intervening between their respective borders.

VIII.—On Some Rock-Specimens from Socotra.

By Miss C. A. Raisin, B.Sc.

THESE specimens were collected in Socotra, near the coast, by Colonel M. Gosset, and were sent to Prof. Rupert Jones. By the kindness of Prof. Bonney I have been allowed to carry on the examination of the rocks, at University College, in connection with the Somali specimens already described.

Granites.—The granites need little description, as they are clearly of types already obtained from Socotra;[1] they consist chiefly of felspar, often microcline, and of quartz. Hornblende crystals, evidently of early consolidation, are imbedded in the felspar. Some of the hornblende is very strongly dichroic, and changes from a faint green to a deep peacock-blue, tints which approach somewhat near those shown by glaucophane. Octahedra of magnetite occur in one fragment, and in others characteristic crystals of zircon are fairly abundant.

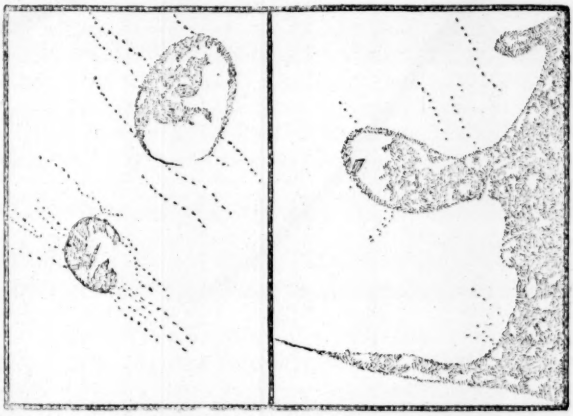
Felstones.—Many of these seem to be quartz-felsites of the red and purple tints, mentioned by Prof. Bonney as so characteristic of Socotra. Two specimens, however, need somewhat fuller description.

(1). Quartz-felsite. This is a very compact, flinty rock, dull-green in colour, blotched with white. The ground-mass is completely devitrified, with small brightly-polarizing microliths scattered through it. The porphyritic hornblende is in partial preservation, but frequently epidote appears to have formed along its cleavage-planes, and spread over the interior of the crystal. Many of the felspars are plagioclase; some have passed to an aggregate of crystalline films, but others appear clarified, with kyanite-like cleavages. The porphyritic quartz is much corroded. Some of the embayments formed of the ground-mass inclose clear, unaltered quartz, generally with a shadowy outer border, as if it had been partially melted down by the surrounding matrix (Fig. 1). In other examples, the invading ground-mass, which has an angular outline, stops short of a curved boundary, marked out by minute cavities often with moving bubbles. Corrosion of crystals has been attributed to the influence of a direct rise of temperature, or indirectly to some cause which increases the fusibility of the matrix and solubility of the crystal, such as an alteration in the amount of

[1] Phil. Trans. 1883, p. 282, On a Collection of Rock Specimens from the Island of Socotra, Prof. Bonney.

pressure,[1] or the introduction of water.[2] If the change in the condition of the rock were rapid, a contraction might result, and might perhaps develope along a curve, a layer of inclosures, as in the effects from pressure demonstrated by Prof. Judd.[3] The strain increased, the curve might become a crack, so that the corroding magma could make its way along the weakened surface, and cause the

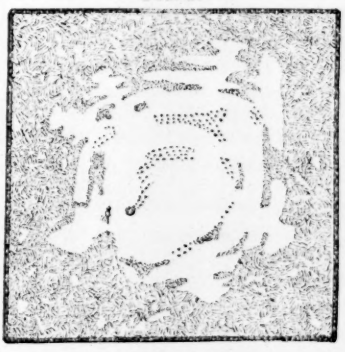
Fig. 1.



Figs. 1 & 2.—Porphyritic Quartz, which has undergone corrosion. The darkened part represents devitrified ground-mass including hornblende flakes. The dots are minute enclosures. The porphyritic quartz is left clear.

interrupted embayments which I have mentioned. The degradation of a crystal may be connected with planes of weak cohesion, as seems illustrated by a grain, which shows very faint, almost concentric zoning; corrosion has originated at seven or eight points along the border of the crystal, and, as it reaches successive zones, has begun to spread along them, resulting in a form like three or four shallow saucers placed one above another (Fig. 2).

Fig. 2.



(2). Orthoclase-Felsite. The hand-specimen is dull, and of a very pale chocolate-brown, with slight traces of fluidal structure. The rock is microporphyritic, crowded with felspars of definite crystalline form, which are decomposed, and contain brightly-polarizing films. From their form, and the occasional occurrence of

[1] Tsch. Min. Mitt. Bd. viii. p. 421; A. Lagorio, Abs. in Min. Mag. 1887. British Petrography, Mr. Teall, p. 407.

[2] Geol. Mag. Jan. 1888, pp. 10, 11, Lavas of Krakatoa, Prof. Judd; Pres. Address Geol. Soc. 1885, p. 54, Prof. Bonney.

[3] Q.J.G.S. 1885, p. 376, On Peridotites of Scotland.

Carlsbad twinning with simultaneous extinction, they appear to be mostly orthoclase. These felspars, and some larger crystals of a pale green hornblende, occasionally twinned, exhibit a certain orientation, which is practically the only indication of a fluidal structure seen under the microscope.

Other Igneous Rocks.—In the diorites, kaolinized felspar, and hornblende mostly in good preservation, are closely intercrystallized, with some appearance of an ophitic structure. One compact black rock occurs, which seems to be of a basaltic character. Another fragment, evidently from a lava-flow, may be a basalt, in which the augite is less clearly individualized, or it may, perhaps, be better classed with the andesites. It contains vesicles, filled up mainly with calcite, but with some chlorite; it has other calcite apparently pseudomorphic, and a zeolitic mineral seems also present. A fairly large cluster of calcite scalenohedra has been sent, and appears to have been formed in or on a greenish felsite, very decomposed fragments of which are found adhering. There is one specimen of a compact black rock, which is rather puzzling, even under the microscope; although it might be a very fine-grained igneous rock of rather basic character, yet it seems most probable that it consists of fine ashy material, with much fragmental felspar in good preservation.

Sedimentary Rocks. (1). *Argillite.*—This is a green flinty rock, with a marked and even banding. It is composed of fine material, and contains small angular fragments with a torn look, many of which are plagioclase. Except that the banding here is more evenly marked, probably in consequence of a pressure, which has acted across the lamination, this rock is very similar to those described by Prof. Bonney. It clearly bears out his suggestion, that the argillites of Socotra are probably not due to local contact metamorphism, but may represent some part of an old sedimentary series.

(2). *Grits.*—In a grit, which appears to consist mainly of fragmental felspar of more than one kind, there seems to have been a secondary deposition, probably of silica, which has remained as a cavernous skeleton, where the original grains have weathered out. Another specimen is composed, almost exclusively, of two of the constituents of a granitic rock—quartz and felspar—and is thus not unlike the Torridon sandstone of the Scotch Highlands.

(3). One specimen of a reddened limestone is very full of fragments of Gasteropod and Lamellibranch shells, the calcite of which exhibits rhombohedral cleavage, and is of a deep red colour, apparently iron-stained.

Except for a few structural characteristics, these rocks are mainly interesting as being an independent collection, which, although small, agrees closely with the description already given of Socotra rocks. The grit, here noticed, may be possibly of recent consolidation, or may belong to the sandstones, which Prof. Bonney mentions as probably present. The groups which he describes will include all the other specimens, except the fossiliferous limestone, although this might belong to the formation of the foraminiferal rock.[1] The

[1] If the limestone belongs to some other series, it might possibly be a representative of Dr. Rochebrune's Neocomians of Ouarsanguélis land.

granites, including among their constituents microcline and hornblende, the felstones, the diorites and other types of igneous rock, and the argillite, are all in close relation to the specimens already described from Socotra.[1]

IX.—Notes on the Nomenclature of the Fishes of the Old Red Sandstone of Great Britain.

By Dr. R. H. Traquair, F.R.S., F.G.S.

THE nomenclature of the fishes of the Old Red Sandstone of Great Britain, with the exception of the Cephalaspidæ, revised some years ago by Professor Lankester, is at present in a very unsatisfactory state. A vary large number of the species named by Agassiz, as well as by McCoy, were undoubtedly founded upon deceptive characters, due partly to different modes of preservation in different rocks, partly also to those apparent variations in external form, which are inevitable in such ancient fossil fishes devoid of a fully ossified internal framework, without which the original outline cannot be expected to be constantly preserved. In specimens from one locality the external ganoid surface of the scales may be well shown, in those from another it may be constantly hidden or obscured, while the proportional measurements in the very same species may vary infinitely, by the fish being lengthened out, or shortened up by changes, which have occurred after death or during the consolidation of the enclosing rock. These and kindred sources of fallacy can only be guarded against by long experience in deciphering such remains, coupled with the examination of an immense number of specimens.

As I am at present engaged on a complete synonymic Catalogue of the Palæozoic Ganoids and Dipnoi in the Edinburgh Museum, I shall limit myself in the following brief "notes" to indicating a few of the principal results which I have obtained in the course of my examination of the fishes of the Old Red Sandstone.

Order Dipnoi.

Family Dipteridæ (*Ctenodipterini*, Pander).

Dipterus, Sedgw. and Murch.—Four species of this genus were named by Sedgwick and Murchison, namely, *D. macropygopterus*, *D. brachypygopterus*, *D. Valenciennesii* and *D. macrolepidotus*. All four were united by Agassiz under the name of *macrolepidotus*, but it was clearly shown by Pander and McCoy that *macrolepidotus* had no place in the original definition of the genus, being possessed of rhombic instead of circular scales. The other three were maintained to be distinct by McCoy, while Sir Philip Egerton, admitting the identity of the first two, still held out for the separation of *Valenciennesii*. After a careful study of the original types in the collection of the Geological Society I fully agree with Pander that *D. macropygopterus*, *brachypygopterus*, and *Valenciennesii* are one species, for which it is desirable to retain the last-mentioned name, given in

[1] Phil. Trans. 1883, p. 273.

honour of the distinguished French ichthyologist. As a synonym it is also necessary to include *Polyphractus platycephalus*, Ag., which was long ago shown to be a *Dipterus* by H. Miller. One species, however, exceedingly distinct from *D. Valenciennesii*, may here be briefly described.

D. macropterus, n.sp. Traq.—Distinguished from *D. Valenciennesii* by the long base and broad rounded contour of the second dorsal fin, and by the thinness of the scales, which permit the outlines of the internal skeleton to be seen through them. The other fins are as in *D. Valenciennesii*, the pectorals and ventrals being beautifully "archipterygial" in their contour.

Lower Old Red Sandstone, John o'Groats, Caithness, Edinburgh Museum, collected by the late C. W. Peach.

Order Ganoidei.
Suborder Placodermata.
Family Asterolepidæ.

Asterolepis and *Pterichthys*.—There can be no doubt that *Asterolepis*, Eichwald, is prior to *Pterichthys*, Agassiz, and if Pander were right in maintaining the identity of the two genera, it would be hard to deny the preference to the first of these names. But Beyrich,[1] Lahusen,[2] and Zittel,[3] accepting Sir Philip Egerton's view that the arms in *Pterichthys* were articulated to "thoracic" plates, distinct from the anterior ventro-laterals, have founded a diagnostic mark on this supposed peculiarity, as such "thoracic" plates certainly do not exist in the Russian *Asterolepis*. But just as little do they exist in the British *Pterichthys*, as an examination of hundreds of specimens has absolutely convinced me that the pectoral limbs were articulated here precisely as in *Asterolepis*. A valid generic distinction may, however, be found in the mode of articulation of the anterior median dorsal plate. According to Pander this plate overlaps both the anterior and posterior ventro-laterals, whereas in *Pterichthys*, though it overlaps the former, it is itself overlapped by the latter. These facts regarding the body-plates of *Pterichthys* were long ago known to Hugh Miller; it is interesting to add that the general structure of *Pterichthys*, including that of the head and arms, is very much closer to that of *Asterolepis* than of *Bothriolepis*, some of whose species,—namely, *hydrophilus*, Ag., *major*, Ag., and *macrocephalus*, Egert., have been included in *Pterichthys*.

Asterolepis maximus, Ag. sp.—The large Asterolepid occurring in the Upper Old Red Sandstone of Nairn (Seabank and Kingsteps), a fragment of whose anterior median dorsal plate was figured by Agassiz as "*Coccosteus*" *maximus*, and afterwards supposed by Hugh Miller to belong to "*Pterichthys*" *major*, seems to me to be referable to *Asterolepis*, as the anterior median dorsal plate most undoubtedly overlaps both anterior and posterior dorsal-laterals. I have now got

[1] "Ueber einen Pterichthys von Gerolstein," Zeitschr. deutsch. geol. Gesellsch. 1877, p. 754.

[2] "Zur Kenntniss der Gattung *Bothriolepis*, Eichw.," Trans. Imp. Min. Soc. St. Petersburg. 1879.

[3] "Handbuch der Palæontologie," vol. iii. pt. 1, pp. 153–157.

together an instructive series of its remains, from which it appears that the head and arms closely resembled those of *Asterolepis* and *Pterichthys*, the limbs being very short, and scarcely reaching beyond the lozenge-shaped median plate of the ventral surface. As a species it is distinguished by the excessive narrowness of the anterior margin of the anterior median dorsal plate, which consequently assumes an almost pointed lanceolate contour.

Species of *Pterichthys*.—I would arrange the British species of *Pterichthys* as follows:

A. Terminal division of arm slender, tapering.
   1. *Pterichthys Milleri*, Ag. (including *P. latus*, Ag.). Inferior surface of carapace broadly ovate.
   2. *P. quadratus*, Eger. Inferior surface of carapace peculiarly short in proportion to its breadth.
   3. *P. cornutus*, Ag. (including *P. testudinarius*, Ag.). Inferior surface of carapace narrowly ovate.

B. Terminal division of arm expanded, abruptly pointed.
   4. *Pterichthys productus*, Ag. (including *P. cancriformis*, Ag.). Inferior surface of carapace narrowly ovate.
   5. *P. oblongus*, Ag. Inferior surface of carapace long and narrow, sides nearly straight.

As the distinctions of form indicated above are actual, and not the result of mere distortion by crushing, I have thought it desirable to retain the groups represented by them as distinct species. Yet so closely do they represent each other in other respects, that very possibly they may only be entitled to rank as varieties. Before coming to these conclusions, I have examined a very large number of specimens in various museums, including all the types save that of *Pterichthys quadratus*, Egert.

Before leaving the subject of *Pterichthys* I may state that I have examined the specimen in the Egerton Collection, British Museum, on which Sir P. Egerton founded his opinion that a pair of ventral fins were present in this genus, and find that the two supposed ventrals are only two portions of the dorsal separated by a little dislocation or fault, a phenomenon of by no means uncommon occurrence in nodules.

Bothriolepis, Eichwald.—When Pander wrote his well-known "Placodermen," he was unacquainted with the structure of *Bothriolepis*, else he would not have included it with *Pterichthys* as one of the synonyms of *Asterolepis*. The dorsal plate figured by Eichwald as belonging to *Bothriolepis ornatus*[1] marks it as one of a group of species, which we now know from Russia, from Great Britain, and from Canada, and whose generic distinctions both from *Asterolepis* and *Pterichthys* are of the most salient kind. Most of these distinctions were pointed out by Lahusen and by Trautschold,[2] but our knowledge of the genus has also been largely increased by the discovery of numerous well-preserved individuals of a Canadian species, which has been figured and described by Whiteaves under the name of *Pterichthys* (*Bothriolepis*) *Canadensis*.[3]

[1] Lethæa Rossica, tab. 56, fig. 3.

[2] Ueber *Bothriolepis Panderi*, Lahusen, Bull. Imp. Mosc. vol. 55, pt. 2 (1880), pp. 169-179.

[3] Trans. Roy. Soc. Canada, pp. 101-107.

In *Bothriolepis* the head plates show considerable differences of shape from those in *Pterichthys* and *Asterolepis*, the most important being the case of the postmedian, which does not extend outwards on each side to join the lateral plate, but, antero-posteriorly hemi-elliptical in contour, is received in a deep rounded notch in the median occipital. The grooves of the lateral line system are differently arranged on the head, and on the anterior median dorsal a prominent groove is seen in the form of an inverted V with the apex near the centre of the plate. The carapace is rather flattened above, and there is a longitudinal dorso-lateral as well as a ventro-lateral sharp inflexion or carina, while the arms are particularly long, sometimes extending beyond the posterior extremity of the carapace. It is odd that no trace of a scaly tail should ever have been discovered in *Bothriolepis* in spite of the perfection of numerous specimens in every other respect, but this by no means proves that the tail itself was absent, only that it had no preservable hard parts.

To *Bothriolepis* belong "*Pterichthys*" *major*, Ag., from the Upper Old Red of Scat Craig, Heads of Ayr, Siccar Point, etc.; "*Pamphractus*" *hydrophilus*, Ag., from Dura Den; "*Pterichthys*" *macrocephalus*, Egert., from Farlow, and I shall here indicate what I consider to be two additional British species.

Bothriolepis giganteus, n.sp. Traq. (= *Bothriolepis ornatus*, Ag. pars, non Eichwald).—Of large size; anterior median dorsal plate gently convex, not carinate, surface of plates covered by rather coarse tubercles more or less confluent into vermicularly contorted sometimes reticulated ridges, and frequently displaying stellate bases. Fragments of impressions of plates of this species were figured by Agassiz as belonging to *B. ornatus*, Eich. (Old Red, tab. 29, figs. 3, 4, 5), but the anterior median dorsal plate is broader in shape than that figured by Eichwald, and the sculpture is also different. Upper Old Red, Alves, near Elgin. I am greatly indebted to the Rev. Dr. Gordon of Birnie and to the Directors of the Elgin Museum for the opportunity of studying the remains of this magnificent species, of which I intend soon to give a detailed description in another place.

Bothriolepis obesus, n.sp. Traq.—Of this I have only seen the anterior median dorsal plate, posterior dorso-lateral, and the anterior and posterior ventro-laterals, the specimens being contained in the collections of the Geological Survey of Scotland, and of the Museum of Science and Art, Edinburgh. The dorsal plate is carinated along the middle line, the posterior dorso-lateral is peculiarly short and deep, the posterior ventro-lateral is remarkable for the great height of its ascending lamina, the contour of these plates indicating a carapace of a proportionally short and "thick-set" aspect. Surface coarsely tuberculated. This is also a large species, and from the Upper Old Red of Rule Water, near Jedburgh. All the British species of *Bothriolepis* are from the Upper Old Red Sandstone, and comprise the largest as well as nearly the smallest of the known forms of Asterolepidæ.

Microbrachius Dickii, n.gen. Traq. (= *Pterichthys Dickii*, C. W. Peach, name only, British Assoc. Rep. 1867, Trans. of Sections

p. 72).—Very small, head and carapace only attaining a length of $1\frac{1}{4}$ inch. Arrangement of head-plates not decipherable, carapace depressed, anterior median dorsal plate broad, overlapped by the posterior dorso-lateral, and also by the anterior dorso-lateral, except towards its anterior angles, where the condition is suddenly reversed; surface minutely tuberculated; arms very short; no trace of tail or of caudal scales. In the Museum of Science and Art, Edinburgh, collected by the late C. W. Peach, from the Lower Old Red Sandstone of John-o-Groats, Caithness.

Owing to the apparently depressed shape and the absence of caudal scales, I should have included this strange little species in *Bothriolepis*, were it not for the shortness of the arms, and the peculiar articulation of the anterior median dorsal plate. I therefore venture to propose a new genus for its reception.

Family Coccosteidæ.

Coccosteus, Agassiz.—With regard to *Coccosteus*, I believe that *C. oblongus*, Ag., *cuspidatus*, Ag., *microspondylus* and *trigonaspis*, McCoy, and *Milleri*, Eger., are all synonyms of *C. decipiens*, Ag. I rather think that *C. pusillus*, McCoy, is also a young specimen of the same species, and if so, then the name *C. minor*, Hugh Miller, should be applied to the small Thurso specimens (see Cruise of the Betsy, chap. x.) collected by Robert Dick, which most certainly are extremely distinct from the ordinary Moray Frith and Orkney examples of the genus. I cannot agree with v. Koenen in referring the specimen figured by Agassiz in his "Old Red," tab. x. fig. 1, as one of *C. decipiens*, and afterwards named by Egerton *C. Milleri*, to his new "subgenus" *Brachydeirus* (see "Beitrag zur Kenntniss der Placodermen des norddeutschen Oberdevons," Abh. Kön. Gesellsch. der Wissensch. 1883), and I may also state that among the hundreds of examples of *Coccosteus* from Scotch deposits which I have examined, I have never found the slightest trace of the pectoral spine, represented in his restoration of *Brachydeirus* (*ib.* pl. iv. fig. 1).

Homosteus, Asmuss.—As there can be no doubt that Agassiz was in error in attributing to Eichwald's *Asterolepis*, Asmuss's "Riesenknochen" from Dorpat, afterwards referred by the last-named author to two genera, *Homosteus* and *Heterosteus*, the name *Homosteus*, Asmuss, must certainly be applied to the "Asterolepis of Stromness," whose remains were first figured by Hugh Miller in his "Footprints of the Creator." As there is no evidence that this gigantic Coccostean belongs to any of these species named by Asmuss, I propose to name it *Homosteus Milleri*.

Suborder Acanthodei.
Family Acanthodidæ.

Mesacanthus, n. gen. Traq. (=*Acanthodes*, Agassiz pars).—The small *Acanthodes*-like fishes of the Scottish Lower Old Red Sandstone differ from *Acanthodes* of the Carboniferous and Permian rocks by the presence of a pair of small intermediate spines in the belly between the pectoral and ventral spines. Here may be

included *Mesacanthus pusillus*, Ag. sp., *M. Peachii*, Egert. sp. (incl. *A. coriaceus*, Egert.), and *M. Mitchelli*, Egert. sp.

Cheiracanthus, Agassiz.—In this genus a multitude of supposed species have been erected upon differences which I have for years been convinced are due merely to various conditions of preservation in different kinds of rock. As absolutely synonymous with the type species *Ch. Murchisoni*, Ag., I include *Ch. microlepidotus*, Ag., *Ch. minor*, Ag., *Ch. lateralis*, McCoy, and *Ch. pulverulentus*, McCoy. But *Ch. grandispinus*, McCoy, and *Ch. latus*, Egerton, are "good species," and are easily recognizable wherever they occur.

Diplacanthus, Agassiz.—The type of the genus, *D. striatus*, Ag., is well known to possess two dorsal spines, four pectoral, two intermediate, two ventral, and one anal. Specifically, I am unable to see any valid distinction between *D. striatus* from Cromarty and Gamrie, *D. striatulus*, Ag., from Lethen and Tynet, *D. crassispinus*, Ag., and *D. gibbus*, McCoy, from Orkney; all the distinctions which have been noted are to my mind due to differences of age and mode of preservation.

Rhadinacanthus, n. gen. Traq. (= *Diplacanthus*, Ag. pars.).—The long, slender dorsal spines of *Diplacanthus longispinus*, Ag., contrast most strongly in appearance with those of *D. striatus*, but a more obvious mark of generic distinction is seen in the absence of the second or lower pair of pectoral spines. There is a pair of intermediate ventral spines between the pectorals and ventrals. As a synonym of *Rhadinacanthus longispinus*, Ag. sp., I feel constrained to include *Diplacanthus gibbus* of McCoy.

Ischnacanthus, Powrie.—This genus, proposed by Powrie[1] for *Diplacanthus gracilis*, Eger., and afterwards withdrawn by its founder,[2] ought to be restored, as this beautiful Forfarshire species is destitute of the intermediate ventral spines with which all the other Diplacanthoid fishes are provided; the powerful dental armature of its jaws is also a well-marked feature of the genus.

Suborder Crossopterygii.

Family Holoptychiidæ.

The Holoptychiidæ emphatically differ from the other Crossopterygian families in having the pectoral fins acutely lobate; the internal skeleton of this fin must have been entirely cartilaginous, but there can be no doubt that it was a "biserial" archipterygium as in *Ceratodus*; the ventrals, however, are only subacutely lobate. The teeth are dendrodont in structure, although, as in the Rhizodontidæ, the laniaries of the mandible, except the most anterior, are set on separate internal dentary ossicles. In the Rhizodontidæ on the other hand the pectorals are subacutely or obtusely lobate, the internal skeleton of both pectoral and pelvic limbs forming an abbreviate uniserial archipterygium, and the teeth are "labyrinthodont" in structure, the dentine of the base being vertically folded in a more or less complex manner, so as to divide the pulp cavity into

[1] Quart. Journ. Geol. Soc. 1864, p. 419.
[2] Trans. Edinb. Geol. Soc. vol. i. p. 289.

a series of vertical tubes, but without the cross branches which in the dendrodont arrangement form an intricate network of vessels. Zittel, in his Handbuch, refuses to accept these families as distinct, but, adopting as a "family" the Cyclodipteridæ of Lütken, divides the genera into—

"(*a*) Unvollkommen bekannte Formen mit dendrodonten Zahnbau (*Dendrodus*, *Cricodus*, ? *Colonodus*, ? *Sigmodus*).

(*b*) Formen mit langgestielten Brustflossen (*Holoptychiidæ*, Traquair).

(*c*) Formen mit kurzgestielten Brustflossen (*Rhizodontidæ*, Traquair)."

Here it may be observed—

First, that there is no reason for separating *Dendrodus* from the Holoptychii, the latter being in fact "dendrodont."

Second, that *Cricodus* (= *Polyplocodus*, Pander), which he includes in his first category, is certainly not dendrodont, but Rhizodont in its tooth structure.

Third, that to include the forms with "lang-" and "kurzgestielten Brustflossen" in one "family" is contrary to current ideas of zoologists as to the limits of such a group, indeed one might as well go back to Agassiz's plan of having "homocercal" and "heterocercal divisions" of such a so-called "family" as in his now discarded "Lepidoidei" and "Sauroidei."

The species of *Holoptychius* are extremely difficult to define, and having only a few days ago received an interesting paper from M. Lohest, of Liége, on this subject, I shall defer their consideration for the present; meanwhile I must express my opinion that the scattered teeth and fragments of jaws known as *Dendrodus* and *Lamnodus* belong to fishes at present known to us by their scales as species of *Holoptychius* and *Glyptolepis*.

The large head figured by Prof. Huxley as that of *Glyptopomus minor*, Ag., certainly belongs to *Holoptychius*, probably *H. Flemingii*, which seems sometimes to have attained a large size. The genus *Platygnathus*, Ag., also does not exist, as *Pl. Jamesoni*, Ag.—concerning which Huxley wrote that it cannot be doubted that it "is very closely allied to *Holoptychius*"—is clearly the tail end of a *Holoptychius* turned upside down, the lower aspect of the caudal being mistaken for an enormous dorsal, and the second dorsal for an anal; while the mandible from Orkney figured by Agassiz as *Platygnathus paucidens*, is with equal certainty referable to the same large species of *Glyptolepis* whose sculptured scales and dendrodont teeth were attributed by Hugh Miller to his "Asterolepis of Stromness" (*Homosteus*). This magnificent *Glyptolepis*, of which the Edinburgh Museum now possesses several entire specimens from Thurso, must therefore stand as *G. paucidens*, Ag. sp.; and as synonyms of *G. leptopterus*, Ag., I must include *Holoptychius Sedgwicki*, McCoy, and *Glyptolepis elegans*, Ag. We shall presently see that *Glyptolepis microlepidotus*, Ag., is not referable to *Glyptolepis* at all, but belongs to a different family.

Family Rhizodontidæ.

The Rhizodonts are not nearly so prominent a group in the Old Red Sandstone as in the Carboniferous rocks, nevertheless their presence both in the Lower and Upper divisions of the first-named formation is attested by several well-marked genera, such as *Tristichopterus*, Egert., from the Lower Old Red of Caithness, and *Eusthenopteron*, Whiteaves, from the Upper Devonian of Canada. There are also others to which I shall now refer.

Gyroptychius, McCoy.—For many years I was much puzzled by this genus, which—originally referred to the "Cœlacanthi" by McCoy—was classed as a "Dendrodont" by Pander, and as a "Saurodipterine" by Egerton. Huxley also placed it in the rhombiferous division of his Glyptodipterini; but if Pander's figures are taken from authentic examples of *Gyroptychius angustus*, McCoy, we have to deal with a typically Rhizodont genus. Accordingly in my account of *Tristichopterus alatus* (Trans. Roy. Soc. Edin. vol. xxvii. 1875) I placed it in the group of Cyclodipteridæ (Cyclodipterini Lütk. excl. Holoptychiidæ), the family designation of which I afterwards altered to "Rhizodontidæ" (Cranial Osteology of *Rhizodopsis*, ib. vol. xxx. 1881). Not having at that time (1875) seen the original specimens, I appended a query, owing to the apparently rhombiferous squamation of *G. diplopteroides*, McCoy. Since that time a careful examination of the types in the Woodwardian Museum, Cambridge, has afforded the following explanation of the puzzle. *Gyroptychius diplopteroides* is nothing but a specimen of *Diplopterus Agassizii*, Traill (*D. borealis*, Ag.), with the ganoid surface of the scales wanting, as is so often the case in Orkney specimens, while *G. angustus* is valid generically, is a Rhizodont, and no doubt the same as the fish whose details have been figured and described by Pander. But more than this, on examining a series of specimens of *Glyptolepis microlepidotus*, Ag., including the types, I was interested to find that this fish had obtusely lobate pectorals, and labyrinthically folded tooth-bases, and is therefore not a *Glyptolepis* nor even a Holoptychian, but a Rhizodont. And on comparing those Moray Frith specimens with those from Orkney referable to McCoy's *Gyroptychius angustus*, so close is the resemblance between the rhombic diphycercal shape of the tail, the position of the fins, the shape and markings of the scales, and other details, that I am forced to the conclusion that *Glyptolepis microlepidotus*, Ag., and *Gyroptychius angustus*, McCoy, are one and the same thing. The genus *Gyroptychius* therefore stands, but *G. diplopteroides* must be cancelled, and for the type species "*microlepidotus*," Ag., must be substituted for "*angustus*," McCoy. I may remark that *Gyroptychius* is one of those genera which, like *Rhizodopsis* of the Carboniferous, closely bind together the families of Rhizodontidæ and Rhombodipteridæ.

Another Rhizodont genus of the Old Red Sandstone (Upper) is represented by the *Bothriolepis favosus* of Agassiz, a mandible of which, from Clashbennie, in the Edinburgh Museum, clearly shows that the teeth were labyrinthically folded at the base as in *Rhizodus*,

which genus it still further resembles in having the laniaries compressed and two-edged towards the apex; these laniaries are however proportionally much smaller in size, and the internal denticles which support them different in shape from those of *Rhizodus*, being broad and flat, instead of narrow and compressed. This species may probably turn out to be generically referable to *Cricodus*, Ag., which, judging from Agassiz's figures of *C. incurvus* and of *Polyplocodus* given by Pander, is certainly a Rhizodont. It will be remembered that "*Polyplocodus*" was the name by which Pander sought to displace "*Cricodus*," on the ground that the latter was descriptively inaccurate.

Rhombodipteridæ.

It is remarkable that although Zittel, in his "Handbuch," includes the Rhizodonts in one heterogeneous family with the Holoptychii, he nevertheless keeps the Rhombodipterines apart, whose close affinity with the Rhizodonts I have indicated in my memoir on the Cranial Osteology of Rhizodopsis already quoted. In fact much is to be said in favour of Prof. Miall's plan of uniting the Rhizodonts and Rhombodipterines in one group, and in this connection I may mention the recent discovery by Mr. J. Ward, F.G.S., of a specimen apparently of *Rhizodopsis* on the scales of which there is undoubted evidence of ganoine, while I think I have myself observed the same phenomenon in the case of the fin-rays of a specimen of *Gyroptychius microlepidotus* from Tynet. But I shall for the present adhere to the arrangement given in my essay on *Tristichopterus*, thereby dividing the Rhombodipteridæ into two subfamilies—Glyptolæmini, in which the scales are sculptured and destitute of ganoine, and Saurodipterini, in which the scales are covered with a layer of ganoine and the elements of the cranial roof and of the mandible have a tendency to fusion with each other.

Saurodipterini.

Osteolepis, Val. and Pentland.—The genus *Osteolepis* is mentioned by Sedgwick and Murchison as having been named by Valenciennes and Pentland with two species, *macrolepidotus* and *microlepidotus*, but, unfortunately, neither figures nor adequate descriptions are given, though Pander identifies as "*Osteolepis*" the figure given in the same paper as that of a young individual of "*Dipterus*" *macrolepidotus*. Agassiz afterwards adopted the name *Osteolepis* in place of his own "*Pleiopterus*," and described the species *macrolepidotus* and *microlepidotus* from the specimens from Orkney in the collection of Prof. Traill. Here I must agree with Pander that Agassiz's "*microlepidotus*" is identical with his *macrolepidotus*, and I feel indeed doubtful if even the latter is the same fish with that originally so named by Valenciennes and Pentland, as I have never convinced myself of its occurrence in the Caithness beds at all. And I must also agree with Pander in considering that the *Osteolepides* from the Moray Frith nodules, namely, "*arenatus*," Ag., and "*major*," Ag., are both synomymous with *O. macrolepidotus* from Orkney, and only differ in their mode of preservation. *O. brevis*, McCoy, of

which I have carefully examined the type, is, to my mind, nothing more than a shortened-up and vertically "squashed" specimen of *O. macrolepidotus*. And, as already surmised by Pander, *Triplopterus Pollexfeni*, of McCoy, is certainly an *Osteolepis macrolepidotus*, so crushed that both ventral fins are visible, one of which has been mistaken for the supposed single dorsal.

The beautiful little Caithness fish, minutely described and figured by Pander as *O. microlepidotus*, is certainly a most distinct species, whether it be that originally so named by Valenciennes and Pentland or not. It abounds in some localities near Thurso, and there is a magnificent set in the Hugh Miller Collection in the Edinburgh Museum.

Thursius, n.gen. Traq. (= *Dipterus*, Segdw. and Murch. pars, *Osteolepis*, Pander pars, *Diplopterus*, McCoy pars).—With the specimen figured by Sedgwick and Murchison as a young individual of "*Dipterus macrolepidotus*," and erroneously adopted by Agassiz as the type of the genus *Dipterus*, I identify with ease a common Thurso species, specimens of which are often seen in museums, sometimes labelled "*Osteolepis*," sometimes "*Diplopterus*." By McCoy it was considered to be a *Diplopterus*,[1] and, strangely enough, identified with Agassiz's *D. macrocephalus*, while many of the heads figured by Pander as belonging to *Osteolepis macrolepidotus* clearly belong either to this, or to a closely allied species. But in reality it belongs neither to the one nor the other genus, seeing that to the *heterocercal tail* of *Osteolepis* it adds the *opposition of the two dorsal fins to the ventral and anal respectively*, as seen in *Diplopterus* and *Megalichthys*.

Having failed in my endeavours to construct a descriptive Greek name for this genus, I have named it after the locality around which its remains are commonly found. Two species are readily distinguishable, and of these the typical one for which we are compelled to adopt the name "*macrolepidotus*" has unfortunately the smaller scales. The other, possessing scales of a remarkably large size, and having the jaws proportionally shorter and broader, I propose to call *Thursius pholidotus*. A species of the same genus, possibly distinct from the above, though closely allied to *Th. macrolepidotus*, is the most abundant fish in the flagstones of South Head, Wick, large numbers of it having been collected by the late C. W. Peach.

Diplopterus, Agassiz.—I cannot admit that there is any specific distinction between the *Diplopteri* of the Moray Frith nodules (*D. macrocephalus*, Ag., and *affinis*, Ag.) and the common Orkney species *D. Agassizii*, Traill (*O. borealis*, Ag.), nor can McCoy's *D. gracilis* be recognized as a "good" species, for reasons already frequently and sufficiently explained.

Suborder Acipenseroidei.
Family Palæoniscidæ.

Cheirolepis, Agassiz.—Concerning *Cheirolepis* I have the same tale to tell. No less than six species of this genus have been described

[1] Pal. Foss. p. 587.

from Orkney and from the Moray Frith beds, namely, *Ch. Trailli*, Ag., *Ch. uragus*, Ag., *Ch. Cummingiæ*, Ag., *Ch. curtus*, McCoy, *Ch. macrocephalus*, McCoy, and *Ch. velox*, McCoy. Most patient observation has however years ago convinced me that there is only one species of *Cheirolepis* as yet known from the British Old Red Sandstone, and that all the differences noted are entirely due to different modes of preservation and crushing. A similar view was long ago expressed by Mr. Powrie (GEOL. MAG. Vol. IV. 1867, pp. 147–152).

NOTICES OF MEMOIRS.

I.—NOTE ON THE RELATION OF THE PERCENTAGE OF CARBONIC ACID IN THE ATMOSPHERE TO THE LIFE AND GROWTH OF PLANTS. By Rev. A. IRVING, D.Sc., B.A., F.C.S.[1]

THE author refers to the discussion raised recently on this question in the pages of the GEOLOGICAL MAGAZINE. In order to test the hypothesis adopted by Professor Prestwich, three series of observations have been made during the past summer on plants exposed, under similar physical conditions, to atmospheres of different compositions. The evidence obtained all points in one direction, and goes to show that, with an increase of the percentage of carbonic acid up to about that of the free oxygen present, the vigour of plant life and growth is also increased, so long as the plants are freely supplied at their roots with water, as we have good reason to suppose was the case with the vascular cryptogams from which the carbonized materials of the Coal-measures are for the most part derived. The author further considers the theory as throwing some light upon a certain stage of development of life upon the earth in later Palæozoic time; the great development of plant growth in the Carboniferous age having served as the means of storage of carbon in the earth's lithosphere, and thus purified the atmosphere so as to render it fit for the development of air-breathing forms of life in the Mesozoic age.

II.—ON THE OCCURRENCE OF IOLITE IN THE GRANITE OF COUNTY DUBLIN. By J. JOLY, M.A., B.E.[1]

IOLITE, not previously noticed in Irish granite, has been found by the author in the granite of Glencullen. It occurs as a microscopical but abundant inclusion in a substance of felspathic nature which is to be found interpenetrating prisms of beryl. Its presence is confined, apparently, to the felspar so intermixed with beryl. The iolite is in twelve-sided basal prisms, showing the faces *I*, *i*-$\breve{1}$, *i*-$\breve{3}$, *i*-$\bar{1}$, *O*. In size up to 0·1 mm. in length, transparent, colourless viewed singly, and presents a vivid and beautiful object in the polarizing microscope. Characteristic features are the basal angles of 150°, 120° or 60°; its generally symmetrical extinction on elongated rectangular sections and the transverse cleavage on such sections. A foliation or plating on *O*, and an oblique twinning-line parallel to *I*, are also frequently met with. Occasionally the crystals occur in radiating groups. Inclosures are rare, generally glass.

[1] Read before Section C. British Association, Bath, September, 1888.

III.—Archean Characters of the Rocks of the Nucleal Ranges of the Antilles. By Dr. Persifor Frazer.[1]

DURING a visit this year to the south-eastern part of the island of Cuba, the speaker had made some examinations of the rocks which form the nucleus of the spurs of the Sierra Maestra, and there is strong reason to believe of the axial range of the entire island and of Jamaica, Santo Domingo, Puerto Rico, and the Windward Islands as well. From the field observations there made, and an examination of the specimens under the microscope, it seems highly probable that these rocks, instead of being igneous extensions of the Tertiary period and later, are in reality of much earlier date, and may not be entirely volcanic.

The considerations which support this view are—

1. Microscopic analysis shows immense alteration to have taken place, and consequently a very long period to have elapsed.

2. The complexity of the congeries of rocks forbids the hypothesis of their having been derived from one mass. Where this congeries, therefore, is unconformably adjacent to the Tertiary, there can be no reasonable doubt that the crystalline rocks are the elder. This point of view was suggested by Mr. Teall, who would consider the argument valid also for the contact with the Cretaceous, and perhaps older series. It is difficult to see why it should not hold equally good for the contact between these crystalline and the Palæozoic rocks as made out by De Castro near Cienfuegos, etc.

3. The characters of the several associated rocks are those which one finds united in very many Archean regions throughout the world.

4. The products of alteration of these rocks are similar to those which one finds in the districts just alluded to.

5. The chemical peculiarities of the iron ores found in contact with these rocks are similar to those which one finds in the ores of the Archean regions, both in the low percentage of phosphorus and in the pyrite and (more sparingly) chalcopyrite disseminated through the ore, and in other respects.

6. If this nucleal mass had been forced up from the earth's interior in a state of igneous fusion, there would not be now (as there are) abundant traces of stratification and structure, implying an original sedimentation.

7. If this mass had resulted from volcanic outflow, there must have been contact-phenomena, and changes induced on the surfaces of the rocks with which it was brought in contact. No such contact-alteration has been observed between these rocks and either of the three groups which meet them.

8. The direction of the range, considered as a whole, lends support to the hypothesis that it is a fork of the Andes which, diverging from the main axis in Guatemala, traverses the peninsula of Yucatan, and in a symmetrical curve sweeps through the highlands of Cuba and Jamaica, Hayti, Puerto Rico, the Windward Islands, and the N.E. coast of Venezuela. This run of high land once inclosed the Caribbean as another Mediterranean Sea.

[1] Read before Section C, British Association, Bath, September, 1888.

9. The shapes of the hills of this range, produced by weathering, are not those usually visible in regions of volcanic, but rather of metamorphic rocks.

The rocks which furnished the basis for the above conclusions are all, or nearly all, alteration-products. In some cases they appeared to be the results of a second, third, or even greater number of metamorphoses, some of their constituents seeming to pass through cycles of change, ending in the mineral with which the alteration began after a number of intermediate stages. The rocks are Diorites, with Epidote, Porphyritic Dolerites, which resemble and have been taken for Syenites; Garnet rock; Actinolite; Felsite and Orthofelsite Porphyry, like that of the South Mountain of South-eastern Pennsylvania, of St. David's Head in Wales, and elsewhere. To these are added Pyrite and iron ores. Copper and manganese ores are not rare, but their relations to the rocks under consideration have not been made out.

IV.—Sur le genre *Euclastes*. By Louis Dollo. Ann. Soc. Géol. du Nord, vol. xv. (1888), pp. 114–122.

A DETAILED discussion results in the conclusion that to the synonymy of the Chelonian *Euclastes* (Cope, 1867), must be relegated the generic names *Lytoloma* (Cope, 1871), *Puppigerus* (Cope, 1871), *Glossochelys* (Seeley, 1871), *Pachyrhynchus* (Dollo, 1886), and *Erquelinnesia* (Dollo, 1887). The genus is thus defined as follows:—Skull very broad and flat. Supratemporal fossæ completely closed by a bony roof. Orbits more or less directed upwards. Nasals distinct. A lateral temporal notch well marked. Palatine expansion triangular, very thick, and almost on the level of the alveolar border. Vomer very long, extending towards the occiput, and separating the submaxillaries and the palatines for a considerable distance. Posterior nares situated much nearer the occiput than in the Chelonidæ. Palatal vacuities for the passage of the temporal muscles extraordinarily broad. Mandible massive, with a very long symphysis. Carapace rounded behind. The Chalk fossil shown in fig. 4, plate vii. A of Owen's "Mon. Foss. Rept. Cret. Form." (Mon. Pal. Soc. 1851) is considered to belong to *Euclastes;* and the genus is also represented in the Upper Cretaceous of the United States, and the Lower Eocene of Belgium and England.

V.—Sur le Crâne des Mosasauriens. By Louis Dollo. Bull. Scientifique France et Belgique, 1888, pp. 1–11, pl. i.

THE fine double plate accompanying this paper is occupied by a profile view of the skull of *Hainosaurus* and another of a less complete skull of *Mosasaurus*, each with an osteological explanation, and the two placed together for comparison. M. Dollo also investigates an interesting minute point in the osteology of the Mosasaurian skull, namely, the significance of the shallow rounded pit upon the proximal half of the quadrate bone. The feature was first noticed by Prof. E. D. Cope, who considered that it probably "received the extremity of an osseous or cartilaginous styloid stapes;" and Sir Richard Owen afterwards suggested that it might have received

"the end of a long outstanding paroccipital process, as in the Lacertilia." The discovery of the actual styloid bone in *Plioplatecarpus* leads to a different conclusion; and M. Dollo considers that the element corresponds to that termed suprastapedial by Parker, the cavity thus receiving the appropriate name of "fossette suprastapédiale."

VI.—*Iguanodontidæ et Camptonotidæ.* By Louis Dollo. Comptes Rendus, March 12th, 1888, pp. 775–777.

IN 1882 Professor Marsh defined the two Dinosaurian families under discussion as follows:—

Camptonotidæ.—Clavicles absent; post-pubis complete (*Camptonotus, Hypsilophodon, Laosaurus, Nanosaurus*).

Iguanodontidæ.—Clavicles present; post-pubis incomplete (*Iguanodon, Vectisaurus*).

In the same year, M. Dollo attempted to show that the supposed clavicles were really sternal bones, and proposed a rearrangement thus:—

Hypsilophodontidæ.—Four functional toes. Sternum consisting of a simple rhomboidal bony plate (*Hypsilophodon*).

Iguanodontidæ.—Three functional toes. Sternum consisting of two bony plates, one left and one right (*Camptonotus, Iguanodon, Laosaurus, Nanosaurus, Vectisaurus*).

A reconsideration of the subject now induces the Belgian Palæontologist to return to Professor Marsh's original arrangement, with amended definitions, thus:—

Camptonotidæ.—Premaxillæ toothed. Sternum unpaired, manus morphologically pentadactyle, and reduced on the ulnar border and in the centripetal direction. Thumb normal. Ossification of the pubis extending to the extremity of the ischium. Fourth trochanter pendent. Four functional pes-digits.

(*a.*) Two phalanges in manus-digit v. Preacetabular process of the ilium slight. No rudiment of pes-digit v. (*Camptonotus.*)

(*b.*) No phalange in manus-digit v. Preacetabular process of the ilium long. A rudiment of pes-digit v. (*Hypsilophodon.*)

Iguanodontidæ. — Premaxillæ edentulous. Sternum paired. Manus morphologically pentadactyle, and reduced on the radial border and in the centrifugal direction. Digit v. normal. Pubis only extending to the distal extremity of the ischium in a ligamentous state. Fourth trochanter crest-like. Three functional pes-digits. (*Iguanodon.*) A.S.W.

VII.—List of Fossil Mammalia. By Dr. Otto Roger. Bericht Naturw. Vereins Schwaben u. Neuburg in Augsburg, vol. xxix. (1887), pp. 1–162.

THIS important work of reference is a new edition of Dr. Roger's list of known fossil mammalia published in the Correspondenzblatt Regensburg. zool.-min. Verein, 1879–82. It incorporates the recent results of Schlosser, Lydekker, Trouessart, and the American palæontologists, and is thus brought well up to date.

REVIEWS.

I.—Some Devonian and Silurian Fossils of North America. By James Hall and J. M. Clarke.

IN continuation of the grand series of monographs on the Natural History of the State of New York, prepared by eminent naturalists and geologists, and issued from time to time at the expense of the State, we have lately received a handsome instalment. This is a thick quarto volume, entitled :—

"Geological Survey of the State of New York. Palæontology: Vol. VII. Text and Plates. Containing descriptions of the Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung, and Catskill Groups. By James Hall, State Geologist and Palæontologist. Assisted by John M. Clarke." 4to. lxiv. and 236 pages, and 45 plates. Together with a "Supplement to Vol. V. Part 2, of the Palæontology of New-York State. Pteropoda, Cephalopoda, and Annelida;" 42 pages, and plates 114 to 129. Albany, N. Y., 1888.

This is a most valuable contribution to our knowledge of the palæontology, chiefly of the Devonian rocks of the State of New York; and is a large addition to the extensive series of State publications, which the veteran Professor Hall has already produced in Albany, N.Y., with the aid of the State Museum of Natural History. In the preparation of the important volume before us, Dr. James Hall states, in the preface, that he has to acknowledge with great satisfaction the able and untiring efforts of his Assistant, Mr. John M. Clarke, both in the preparation of the matter for the press, and in the critical study of the material. With such fossils Mr. Clarke's long-continued researches have made him well acquainted, as shown to a great extent by his previous memoirs.

A study of the descriptions and figures of the Trilobites, forming the first 152 pages and 34 plates, particularly impress us with the fact of a close similarity of the North-American Devonian forms to those of Europe. Many of the genera, as *Calymene*, *Homalonotus*, *Phacops*, *Dalmanites*, *Lichas*, and *Proëtus* suggest to some extent an Upper-Silurian facies, as found in this country; and some, as *Phacops* and certain forms of *Proëtus*, seem to be closely related to the Devonian species of the Eifel.

Attention is arrested by such species here figured as *Dalmanites regalis*, in which the front border is ornamented with a symmetrical denticulation, consisting of distinct, subquadrate, tooth-like processes, resembling the cog-wheels of a clock. These are shown in *Dalmanites Ægeria* to have united one to the other along the outer margin, leaving hollows between their bases. Such a structure is seen also in *Trinucleus*, as figured and explained by the late J. W. Salter and Dr. H. Woodward.

Some of the figures given of *Homalonotus*, *Dalmanites*, and *Lichas* admirably convey the idea of the great size attained by several of the species, and of the rich and grotesque ornamentation frequently present.

Three plates and ten pages of description are given to the Limulidæ and Eurypteridæ. The former has but a poor representative (*Protolimulus Eriensis*). Of the latter, *Stylonurus excelsior*, known by a perfect head-shield and portions of its maxillipeds, was a veritable giant among Devonian Crustacea, and is well figured in two large plates. Other smaller Eurypterids are described and figured. The *Equisetides Wrightianus* is here referred to *Stylonurus*; for that genus, however, the three body-segments preserved appear to be too slender and cylindrical (see GEOL. MAG. 1884, p. 395). We may venture also to suggest that *Eurypterus Beecheri*, with its long slender swimming feet, may really belong to the genus *Stylonurus* (see GEOL. MAG. 1888, p. 420).

Under the PHYLLOCARIDA are given—(1) The Ceratiocaridæ, with *Ceratiocaris* (3 species), *Echinocaris* (7 species), *Elymocaris* (2 species), *Tropidocaris* (3 species); (2) the Pinocaridæ, with *Mesothyra* (4 species), *Dithyrocaris* (1 species); (3) the Rhinocaridæ, with *Rhinocaris* (2 species); the Discinocaridæ, with *Spathiocaris* (1 species), and *Dipterocaris* (3 species). Under the PHYLLOPODA we find *Estheria* and *Schizodiscus*, of the Limnadiadæ, each with one species.

Of the species here described ten have been already published by Mr. J. M. Clarke, and he now adds seven new species. The genera *Mesothyra*, *Rhinocaris*, and *Schizodiscus* are also newly proposed by Mr. Clarke. Of the other Phyllocarids most have been described by Messrs. Whitfield and Beecher. These interesting, but little-known, Devonian Phyllocarids are here conveniently brought together in eight excellent plates, with forty-seven pages of description.

Before leaving the Crustacea, we find twelve pages and one plate devoted to the Devonian Cirripedia of the district under notice. The most remarkable forms here described belong to the Balanidæ, a division of the group not heretofore noticed in strata earlier than the Chalk formation in England, and the Carboniferous of Saxony. Two forms of these sessile Cirripeds (*Protobalanus*, Whitfield, and *Palæocreusa*, Clarke) are figured and described. The latter is found imbedded in *Favosites*, just as similar living forms are parasitic in Corals.

A new genus of Lepadidæ (*Strobilepis*, J.M.C.), characterized by spinous and delicately punctate valves, is figured and described; also eight species of *Turrilepas*, founded on detached valves. There may be a doubt as to the specific distinctness of some of these latter, seeing that in the groups of Lepadidal valves found together in England several rows of differently shaped valves are associated in the test of one individual. Mr. Clarke has evidently noticed this condition to a considerable extent in the American forms among the detached valves.

The Supplement of Vol. V. follows the above-mentioned Vol. VII., with an account of various Silurian Pteropods, Annelids, and Cephalopods. *Tentaculites*, *Hyolithes*, *Styliola*, *Coleolus*, and *Pharetella*, as Pteropoda, take 3 pages and 1 plate. The Tubicolar Annelids, with 15 pages and three plates, are all grouped as *Cornulites*.

One of the plates especially gives the development of the *Cornulites* of the Hudson-River group in various stages of growth.

In thirteen fine plates and sixteen pages of text several species of *Orthoceras*, *Gomphoceras*, *Cyrtoceras*, *Gyroceras*, *Nautilus*, and *Goniatites* from the Palæozoic rocks of North America, are well treated as part of the Supplement to Vol. V.

In the Preface Prof. Hall briefly gives the history of the volume before us, and of the material and plates still remaining on hand for want of funds necessary for the publication, and acknowledges the liberality of many friends and Institutions in having lent him specimens for study and comparison.

In the Introduction a bibliographic history, a classified list, and a chronological or stratigraphical distribution of the Devonian Trilobites and other Crustacea of North America are concisely given. A synopsis of the genera, with synonyms and sketches of types, form a very useful part of the Introduction. Our readers will thus see that Geologists, both at home and abroad, will greatly profit by the labours of Prof. Hall and Mr. Clarke in the Albany Museum: and it is hoped that the State of New York will be able to make the requisite appropriations for the furtherance of Prof. Hall's earnest desire to work out a complete exposition of the Fossils of the State, and to finish the revision of such as in his opinion require renewed criticism.

II.—Dr. Anton Fritsch on *Ctenodus* and other Palæozoic Dipnoan Fishes.[1]

DR. FRITSCH'S great work upon the Permian Vertebrata of Bohemia has now progressed as far as the fishes, and the new part just issued treats of the interesting Dipnoan genus *Ctenodus*. As in the previous parts, devoted to higher Vertebrates, the text is accompanied by numerous woodcuts, in addition to the beautifully executed plates; and every known fossil throwing light upon the subject is amply discussed, no less than ten of the figures representing specimens that are not Bohemian, and six being devoted to important features in the skeletal anatomy of the living *Ceratodus*.

The Professor commences by emphasizing the intimate relationship existing between the genera *Ctenodus* and *Ceratodus*, and continues the introductory remarks by some brief reference to *Megapleuron*, *Conchopoma*, and *Phaneropleuron*, which he also considers to be close allies. An examination of the type-specimen of *Megapleuron* has convinced Dr. Fritsch that its supposed rhombic scales are truly those of a Palæoniscid mingled with the skeleton—a conclusion which the writer of this notice has also been able to confirm; and doubts are expressed as to whether Kner may not have been misled by a similar accident, when he assigned rhombic scales to *Conchopoma*. The latter is a more uncertain case; the scales of *Conchopoma* are small, thin, and striated; and the suggestion that the teeth of

[1] Anton Fritsch, "Fauna der Gaskohle und der Kalksteine der Permformation Böhmens," Band ii. Heft 3 ("Die Lurchfische, Dipnoi, nebst Bemerkungen über silurische und devonische Lurchfische"), pp. 65—92, pls. 71—80. (Prag, 1888.)

this genus may eventually prove to be so arranged as to appear the homologues of the dental cusps of *Ctenodus tuberculatus* has also still to be substantiated by future discoveries.

Ctenodus is defined as "a Dipnoan of *Ceratodus*-like structure. Dental plates with many notched ridges. Dermal bones of the head more numerous than in *Ceratodus*. The hyoid and the entire skull more elongated than in *Ceratodus*. The skeleton more completely ossified than in *Ceratodus*, but otherwise agreeing with the latter in detail. Scales large, thin, of elongated quadrangular form, bearing traces of fine rows of denticles; with vascular grooves on the under side." All the portions of the skeleton are then described under the heading of *Ctenodus obliquus*, Hancock and Atthey, it being quite impossible to separate the bones of a second species (*C. applanatus*, Fritsch) that also occurs at Kounová. The more important fossils were obtained from the pyritous shales in the latter locality; and it is disappointing to read that Dr. Fritsch's admirable galvanoplast reproductions of the Stegocephalians met with so few purchasers, that it has been deemed impracticable to secure permanent copies of these new destructible Ichthyolites by the same costly process.

In the skull of *Ctenodus* there are several ossifications in parts that remain permanently cartilaginous in *Ceratodus*; and many interesting comparisons are made. A bone that was formerly described as the pelvis of a Stegocephalian, is now recognized as the squamosal of *Ctenodus*. The cranial roof bones appear to defy all attempts at definite nomenclature; and there is no distinct evidence of ossified maxillæ and premaxillæ. The opercular bones, with the exception of the operculum itself, are also not yet capable of certain determination. With regard to the mandible, Dr. Fritsch identifies a small fossil with the thin plate described by Huxley in *Ceratodus* as the dentary element; and a figure is given to illustrate the insignificant dimensions of this bone, and the importance of its claims to recognition as a peculiar "dermomental" element. The small development of the dentary bone, however, in certain Mesozoic Ganoids with crushing teeth (e.g. Pycnodonts and *Belonostomus*), seems to render the original determination quite as plausible as that now suggested by Dr. Fritsch.

The teeth referred to *C. obliquus* in the present monograph were at first made known by Dr. Fritsch under the name of *Ceratodus Barrandei*; and an interesting series is figured to show the changes that appear to take place in the dentition during the growth of the fish. The Professor remarks:—"We possess a series of the teeth, from 11 to 54 mm. in length, and there is really no doubt that these belong to different stages in the life-history of a single species. They are two and a half times as long as broad, and the number of notched ribs varies from 7 to 9. The most anterior seven ribs are especially prominent, but the eighth and ninth are at times indistinct, and then follow two or three small tubercles, which represent additional crimped ribs. The ribs decrease in length backwards, so that the seventh is only half as long as the first. The crimping is mostly

indistinct on the first rib, and, notwithstanding the difference in the length of the ribs, the others all have an equal number of outwardly directed cusps. The smallest examples exhibit five cusps on each rib, the largest, seven to nine. In very old teeth, the inner crimpings become indistinct. With increasing age, also, the dental plate becomes arched; while the smallest young teeth are comparatively flat, the largest old examples appear arched above, as shown by a comparison of the profile figures. The small dental plates correspond to those that have been named *C. elegans*, H. and Atth., in England; the large ones agree with *C. obliquus*, H. and Atth." No vomerine teeth have hitherto been detected in Bohemia, and figures only of an English specimen are thus given. Some remarks are made upon the microscopical structure of the teeth, with illustrative drawings of sections; and it is pointed out that in the vasodentine of *Ctenodus* the vessels are more branched and anastomosing than in *Ceratodus*.

Proceeding to a discussion of the axial skeleton of the trunk, Dr. Fritsch considers that there is evidence again of an extremely close approximation to *Ceratodus*. The notochord seems to have been persistent, with slight ossifications in the sheath; and the first rib is considered to have been relatively very stout, as in the existing genus. Many of the ribs show traces of having been broken and repaired during life.

The brief sections upon the appendicular skeleton bear witness once more to the laborious and exhaustive character of the investigations made by Dr. Fritsch in regard to the most unpromising fragments. None but isolated bones of the limbs and their supporting arches have hitherto been discovered; but an attempt is made to restore the pectoral arch—consisting of a greater number of elements than that of *Ceratodus*; and again, attention is directed to the high degree of ossification of all the parts.

The last plate is devoted to an interesting comparison of the scales with those of *Ceratodus*. The outer side of each scale "appears smooth in the middle, and is only seen to be rugose when highly magnified. The border exhibits concentric lines of growth, of varying width, parallel to the margin. Across these extend small parallel ridges, on the middle of which are rows of minute pits, apparently indicating the spots that originally supported denticles." Another noteworthy feature is the forked appearance of the sensory canal upon a detached scale of the lateral line—a condition unknown in *Ceratodus*.

As the result of his researches, Dr. Fritsch considers that the Bohemian examples of *Ctenodus obliquus* must have attained a length of about 140 centimetres. "The greater number of the dermal bones in the skull, added especially to the stronger ossification of the entire skeleton than in the case in *Ceratodus*, parallels what we have observed among the Permian Amphibia, which also have the skull better armoured than their now living allies."

Ctenodus applanatus, Fritsch, is defined as having flattened upper teeth, only twice as long as broad, with sharp but scarcely crenated

ridges; and a new species, *C. trachylepis*, is founded upon detached scales from Nyřan.

The concluding section of the Monograph relates to some fragmentary evidence of Dipnoan fishes from the Silurian and Devonian formations. A new genus and species, *Dipnoites Perneri*, is indicated by a supposed head-bone from the Upper Silurian (Stage G. 3) of the neighbourhood of Prague. A new and more satisfactory figure of the type-specimen of *Gompholepis Panderi*, Barrande, is next given; and this, too, is regarded as a dermal bone of the cranial roof of a Dipnoan—an interesting bone of *Ctenodus* being figured for comparison. Dr. Fritsch adopts Traquair's determination of the Dipnoan character of *Palædaphus*, and claims to have arrived at the conclusion independently; he then adds a new figure of *Phyllolepis concentricus*, Agass., considering this fossil as probably the head-bone of a closely-allied fish; and *Archæonectes pertusus*, H. von Meyer, and *Holodus Kiprijanovi*, Pander, are finally briefly noticed, the type-specimen of the former being regarded as the bony portion of the palate, wanting the teeth.

Dr. Fritsch appends a synopsis of the literature of the subject (in which we miss a reference to two important papers by W. J. Barkas, in the Proc. Roy. Soc. N. S. Wales, 1876-7); and a list of the known genera of Palæozoic Dipnoan Fishes is given as follows:—

Silurian.—*Gompholepis*, Barrande, *Dipnoites*, Fritsch.

Devonian.—*Palædaphus*, Van Beneden and de Koninck; *Phyllolepis*, Agassiz; *Archæonectes*, H. von Meyer; *Holodus*, Pander; *Conchodus*, McCoy; *Mylostoma*, Newberry.

Carboniferous and Permian.—*Megapleuron*, Gaudry; *Campylopleuron*, Huxley; *Conchopoma*, Kner; *Phaneropleuron*, Huxley; *Ctenodus*, Agassiz; *Ptyonodus*, Cope; *Gnathorhiza*, Cope.

The genus *Strigilina*, Cope, is also added, but we would remark that that has already proved to be founded upon a tooth of *Janassa*.

It is fortunate for Vertebrate Palæontology that the Bohemian fossils have fallen into the hands of so painstaking an investigator as Dr. Fritsch; and we eagerly await the appearance of the remaining parts of this great work, which will treat of ichthyolites of a still more satisfactory character than those now described under *Ctenodus*.

A. S. W.

REPORTS AND PROCEEDINGS.

The International Geological Congress.

Rarely, if ever, has so large a number of distinguished geologists been drawn together as were assembled in the University of London on the opening of the fourth session of the International Geological Congress on the 17th of September. The presidential address by Professor Prestwich, delivered in faultless French, traced in brief the history of the Congress and forecast its future work. After the delivery of this address in the theatre of the University, the members were received by Prof. and Mrs. Prestwich in the Library,

which had been transformed, by the exertions of Dr. Hinde and a few fellow-workers, into a temporary geological museum. This museum remained open during the week, and proved a permanent centre of attraction, while its value was increased by the publication of an excellent Catalogue, copies of which were distributed among the members.

On Tuesday morning the discussions were centred on the classification of the Cambro-Silurian strata. The general opinion was decidedly in favour of recognizing three divisions. Mr. Marr suggested that the three groups should be united under the name of *Barrandian*. Dr. Hicks and some other speakers advocated the use of Prof. Lapworth's term *Ordovician* for the group of strata intermediate between the Cambrian and Silurian; but this compromise, though offered in a spirit of conciliation, was not generally accepted. No votes were taken at this or at any other meeting, but the discussions were nevertheless of value in that they served to elicit the feeling of the principal members. The method of voting followed at previous meetings has been revised, so as to avoid in future any undue advantage being enjoyed by the country in which the Congress is assembled.

The sittings on Wednesday and Thursday mornings were occupied mainly with the discussion of questions bearing on the nature and origin of the crystalline schists. A number of valuable contributions from foreign geologists had been printed in advance and circulated among the members; but in compliment to our guests the views of British geologists were excluded from this volume. A paper by Dr. Reusch, dealing with the crystalline schists of Norway, was received too late for insertion, but will appear in the final Report.

One of the most useful efforts of the Congress is directed to the preparation of an International Geological Map of Europe on a scale of 1 : 1,500,000. M. Hauchecorne submitted to the meeting specimens of the first sheet of this map. It had been printed at Berlin in the colours recommended by the Map Committee of the Congress, the general principle followed in the colouring being that the older the formation, the deeper is the colour. The effect of the map was eminently satisfactory, and though some of the colours differ widely from those employed for corresponding formations in this country, it received general commendation.

Excursions were organized during the week to Crayford under Mr. Whitaker, and to Windsor with Mr. Drew and Dr. Carpenter. Visits were made to both sections of the British Museum, one under the direction of Mr. Franks, the other under Prof. Flower; and to Kew Gardens with Mr. Thiselton Dyer. In the evenings receptions of a brilliant character were held by the Director-General of the Geological Survey and by the President of the Geological Society.

On the conclusion of the week's work the members dispersed in various directions, most of them taking part in excursions which had been organized, under competent leaders, to North Wales, East and West Yorkshire, East-Anglia, and the Isle of Wight. The Ex-

cursion Guide-book, edited by Mr. Topley, formed a thick volume illustrated by coloured maps and by numerous sections. It is to be regretted that the cost of printing the literature, which was freely distributed, and other expenses incidental to the meeting, have been heavier than was anticipated, and it remains to be determined how the cost of issuing the final Report is to be met.

CORRESPONDENCE.

OCCURRENCE OF A TOOTH OF THE BLUE SHARK (*CARCHARIAS GLAUCUS*) IN THE BRICK-EARTH OF CRAYFORD, KENT.

Sir,—I have lately received from a member of the Geologists' Association, Mr. Henry E. Jones, of Ealing, an interesting Selachian tooth from the Thames Brick-earth at Crayford, Kent. The specimen was discovered by Mr. Jones himself in the well-known pit from which the numerous Mammalian remains are obtained; and its mineral condition is such as to leave no doubt that it is a true Pleistocene fossil. The tooth may be assigned without much hesitation to the symphysial region of the lower jaw of an adult Blue Shark (*Carcharias glaucus*), about 8ft. in length; and the fact that it is merely a hollow germ, and yet unbroken, shows that it cannot have been subjected to much rough usage before entombment. Many of the Selachian remains of Pliocene deposits are practically indistinguishable from the corresponding parts of living species still inhabiting the Northern Hemisphere; and it is natural to expect that similar forms will be found in beds of Pleistocene age. At present, however, we are only acquainted with evidence of *Galeus canis*, *Acanthias vulgaris*, *Raja batis*, and *Raja clavata*, described by Mr. E. T. Newton from the Forest Bed Series of Norfolk; and the new Crayford discovery is still more interesting on account of the distance of the locality from the existing coast-line.

Arthur Smith Woodward.

MISCELLANEOUS.

We learn that Professor J. W. Spencer, M.A., Ph.D., F.G.S. (late of the University of Missouri), who has contributed several papers to this Journal upon Glacial phenomena in Europe and America, has recently been called to the Chair of Geology in the University of Georgia, Athens, Georgia, U.S.A.

Erratum.—In the October Number on page 434, line 27 from top of page, for "*ex*opodite" read "*end*opodite."